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BIOGEOGRAPHIC AND TAXONOMIC STUDIES IN ATOPSYCHE

(Trichoptera, Rhyacophilidae)[1]

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The genus *Atopsyche* is a small group of rhyacophilid caddisflies containing about twenty species. It is confined to the warmer areas of the Americas, ranging from southern Texas and Arizona to northern Argentina. Information to date indicates that the larvae occur only in clear, cold, rapid streams, usually spring fed, a relatively infrequent habitat throughout the range of the genus.

When we first began our studies of *Atopsyche*, the primary objective was simply to make a rough comparison of the Mexican fauna with that of South America. As the studies progressed definite phylogenetic patterns emerged which coincide to a remarkable degree with certain paleogeographic features of Central America. We have therefore attempted to correlate these two features and have found some very interesting dispersal patterns indicated, despite the sparse nature of South American collections.

Most insect genera containing many species are quite old, dating back at least to pre-Oligocene times, and many of them have spread far from the area in which they originated. As a consequence it is necessary to study the detailed phylogeny and distribution of the species comprising such genera in order to find information regarding the origin of ancestral forms within the genus and the dispersal of their progeny. *Atopsyche* falls in this general category, although it is not so widespread as other caddisfly genera such as *Hydropsyche* or *Oecetis*, which are virtually world-wide.

[1]This paper is a joint contribution from the Section of Faunistic Surveys and Insect Identification, Illinois Natural History Survey, and the Department of Entomology, University of Illinois.

PRINCIPAL CHARACTERS

Since the segregation of the species of *Atopsyche* is based entirely on characteristics of the male terminal structures, a brief discussion of their essential features may be of some value.

The *paracercus* (fig. 23A, pc) is a paired structure fused solidly to either side of the caudo-dorsal edge of the last sternite. It is extremely variable in shape, and is frequently armed with spines and heavily sclerotized teeth.

The structures termed "side pieces" by Mosely (1931) are considered to be the cerci by us. They are invariably present on the caudo-lateral margins of the last sternite, (fig. 23A, c) may be slightly elongate or reduced to mere buttons, and bear strong setae at their tips.

The *filicercus* (fig. 23A, fc), when present, arises mesad of the base of the side piece. It varies in length and shape, but never departs far from the filiform.

The *claspers* (fig. 3A, cl) are typically two-segmented, though in one species the suture between the two segments has disappeared. *A. batesi* was originally described as having a three-segmented clasper, based on an examination of the genitalia in a dry condition, but clearing and mounting the specimen shows that the clasper is really two-segmented.

The *aedeagus* typically has a bulbous base and is attached internally to the last visible sternite by means of a ventral lip-like protuberance. For the greater part of its length it is divided into two more or less fleshy, somewhat divergent lobes, designated in descriptions as the *principal lobes* (fig. 23c, pl). The principal lobes may be ornamental with a variety of sclerotized or non-sclerotized hooks, horns, or processes. Originating in the dorsal part of the aedeagus' base is a slender, curved, *inner rod* (fig. 20B, ir) which is nearly as long as the principal lobes and lies between them. In one group of species there occurs an unpaired *dorsal rod* (fig. 16B, dr), bifurcate at its base, which rests saddle-like upon the base of the aedeagus and is loosely attached to it.

PHYLOGENY

Considering the small number of species involved, the species of *Atopsyche* reveal a startling array of differences. Each part displays many shapes, and no one follows a simple line of increasing complexity through the entire genus. It has therefore been necessary to group the species first as well as possible, and proceed from this point to deducing the relationships of the groups.

Starting with characters of a striking nature which are common to two or more species, we can segregate the species of the genus into these groups:

1. *Batesi group.*—Having a curious unpaired dorsal rod associated with the aedeagus, fig. 15B, these also have in common a projection of the basal clasper segment extending above or below the apical segment. Includes *batesi*, *majada*, and *trifida*.

2. *Falina group.*—Having an apico-ventral lobe of the basal clasper segment, fig. 18A; these also have a short, simple apical clasper segment, and a curious dorsal structure on the aedeagus. Includes *falina* and *lobosa*.

3. *Longipennis group.*—Having what appears to be a double apical clasper segment, fig. 20A, caused by a projection of the basal segment similar in shape to, and paralleling, the apical segment. Includes *longipennis, iana, japoda,* and *hamata.*

4. *Ikonnikovi group.*—Paracercus with two preapical sharp points, one of them high, and apical segment of clasper constricted near middle, fig. 10A. Includes *boneti, dampfi,* and *ikonnikovi.*

5. *Tripunctata group.*—Apical segment of clasper broad at base and ovate or trianguloid, fig. 6A. Includes *tripunctata, cira, aplita, erigia, sperryi, calopta,* and *espala.*

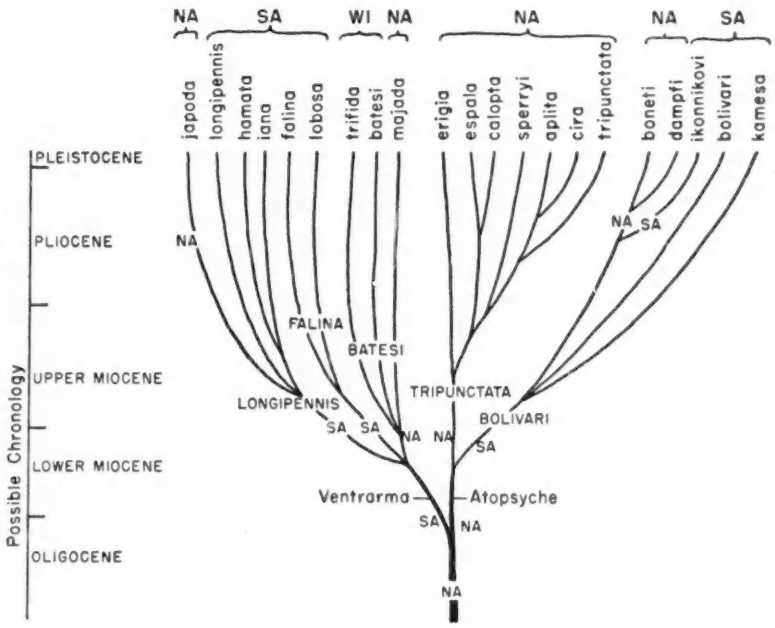


FIG. 1. Phylogenetic tree of *Atopsyche*. *NA*, North America; *SA*, South America; *WI*, Greater Antilles.

6. *Kamesa group.*—Apical segment of clasper clavate, fig. 14A. Includes only *kamesa.*

7. *Bolivari group.*—Paracercus extremely long and thread-like, fig. 13A. Includes only *bolivari.*

If we compare the entire list of species again for common characteristics it is noted that

1. Every group except *bolivari* has at least one species in which the paracercus ends in a dorsal point and has a dorsal point basad of this, and

2. Every group has at least one species in which the aedeagus is

basically elongate and simple, as in fig. 6B (disregarding in this connection the dorsal rod of the *batesi* group).

With this information it seems possible to deduce the condition of the genitalia in the primitive ancestor of the genus. Based on conditions in other Hydrobiosini, the ancestral *Atopsyche* possessed a simple, two-segmented clasper like that in *erigia* or *sperryi*. The aedeagus was simple and somewhat elliptic, with a curved, inner rod. The paracercus had an apical point and a single preacpical process.

In the *tripunctata* group, *erigia* possesses the pointed paracercus, *sperryi* the elongate, simple aedeagus. It seems safe to say, therefore, that a form combining the generalized features of these two species was the ancestor of the entire genus. If we orient our groups in relation to this ancestor we obtain the following solution.

The *tripunctata* group as a whole has remained remarkably generalized. The *boneti* group is most closely related to it, differing fundamentally only in having the apical segment of the clasper narrowed. This same characteristic indicates that *bolivari* also belongs here, and should be considered a sister branch of the *boneti* group. It is also probable that *kamesa* arose as a distinctive branch from the base of a combined *boneti-bolivari* branch. At least *kamesa* has a fairly generalized paracercus and *bolivari* a generalized aedeagus, indicating a separation of these two lines and also the *boneti* group from a common progenitor generalized in both characters. To express this relationship we are grouping these three groups into a single major group, termed the *bolivari* group, and treating the three component parts as species complexes.

The relationships of the *batesi*, *falina*, and *longipennis* groups pose a real problem. It is entirely possible that each group arose independently from the generalized *Atopsyche* stem. Because all have developed specialized processes at the apex of the basal clasper segment it seems more likely that the three arose from a common branch of the *Atopsyche* stem. There is little doubt that the *batesi* and *falina* groups are closely related because of the similarity of the basal clasper segment in some species of both groups.

The curious mesal thumblike process at the apex of the basal clasper segment of the *longipennis* group could have been the result of a simple mesal folding or movement of a ventral process such as in *falina*, and it is probable that this is where and how the "inner thumb" originated. On these grounds we are adopting the view that the *longipennis* group arose from the same stem as the *batesi* and *falina* groups.

In studying these lines further we note that, whereas the dorsal processes of the aedeagus in the *batesi* and *falina* groups may appear similar, in reality these structures are not at all homologous. In the *batesi* group this dorsal structure is connected by membrane to the sides of the aedeagus and articulates freely with it; in the *falina* group the structure arises as a solid outgrowth of the aedeagus proper. The two groups, therefore, arose not one from another but from a more primitive, simple form ancestral to both. This ancestor probably had a clasper like that in *falina* and a simple aedeagus like that in the first *Atopsyche*. In the *falina* line change involved chiefly dorsal ornamentation of the aedeagus. In the *batesi* line change involved first the evolution of the curious articulating dorsal appendage and then differ-

ences in many other parts. Of the three known species of the *batesi* group, ***majada*** has a clasper most closely resembling the postulated ancestral type, but has lost the suture between the two segments.

The *longipennis* group contains forms with a very simple aedeagus (*japoda*) and a simple paracercus (*iana*), indicating that it arose from

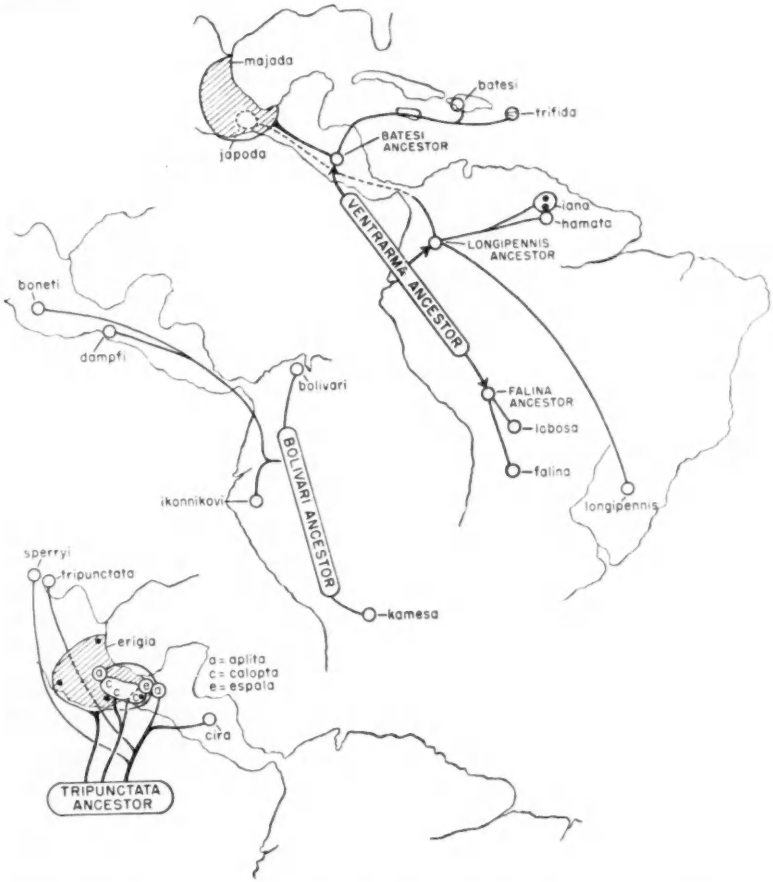


FIG. 2. Diagrams representing distribution of deduced ancestors and dispersal patterns of groups of *Atopsyche*.

an ancestor with these parts very simple. This is essentially the ancestor of the *batesi* and *falina* lines also, so that it appears that these three groups arose from the fracturing of a single ancestral *Ventrarma* species into three segments.

The relationships here outlined are charted in fig. 1, and outlined above.

BIOGEOGRAPHY

The interpretations made in this paper need a qualification and an explanation of the working hypothesis employed. The qualification is that the results are preliminary, because many of the species are known from only one or two localities, and because it seems certain that many more species will be captured with future collecting. Thus the additional data to be expected in the future will undoubtedly cause considerable modification and, we hope, extension of the results reported here. We believe, however, that the data investigated show definite indications concerning the areas of origin and paths of spread in *Atopsyche*, indications which may be of value in comparative biogeography.

Correlation of ecological and morphological characteristics

The working hypothesis employed is, roughly, that a species becomes adapted to a particular ecological niche and stays there as long as it survives. If the species, or a part of it, is able to move into a different ecological niche, selection pressures of the new environment will favor beneficial genetic changes in the population. The result will be a change in the population or species. If, then, many species arise from one through geographic isolation, the least changed or primitive species should represent the one still remaining in the ancestral habitat, and the most changed or specialized species should represent the one in the habitat differing most from the ancestral type.

This is contrary to the idea expressed by many authors that specialized species crowd their primitive ancestors out of the ancestral range *into other habitats*. This latter idea assumes that competitive pressure will drive a species into adjoining territory to which it is not physiologically adjusted, for if it had been so adjusted, the species would have spread into the adjoining territory without any pressure. We are fully aware of the fact that a specialized species may extend its range into that of a more generalized relative, but we believe the result would be either (1) the extermination of the less successful species, or (2) the restriction of the latter to *that portion of its original range* in which it was more successful than the invading species. It seems to us that these expected results are the logical outcome from the application of the directions of selection pressures as outlined by Simpson (1944).

Replacement of a different sort accrues from phyletic evolution when it occurs without multiplication of species. This, however, is a phenomenon outside the point under discussion.

We make another assumption in this paper, that morphological change in male genitalia is correlated in general with degree of physiological change related to habitat. In other words, we assume that forms such as *erigia* which approach the deduced ancestor in almost every morphological feature, are also similar to this ancestor in habitat adaptation. Since the male genitalia furnish the primary basis for determining the phylogeny, this is the only assumption that can be used as a working basis.

Spread vs. Migration

In connection with these ideas on the ecological adaptation of species we would like to re-emphasize a point made by several writers,

namely, that normally a species *spreads* into new territory rather than *migrates* into it. There are true migrations of various types, ranging from rythmic annual migrations of many birds to the irregular outbreaks and mass movements of lemmings, mormon crickets, and migratory grasshoppers. Rythmic migrations occur within what is usually considered as the normal range of the species, and are not in themselves a factor of rapid range shifts. In most cases, mass movements appear to have little effect on the species range over a long period; after such a movement the species usually shrinks back to the range it occupied before.

A species range, however, is amoeboid in character. The species will extend as far in every direction as its ecological tolerance will permit. During periods when ecological factors are less severe along one periphery, the species will extend its range in that direction. In the case of many caddisflies this would be at the rate of only a few miles per year, that is, the dispersal radius of the adults of one generation. During periods when ecological factors are more severe along a periphery, the species would be wiped out in this area, resulting in a contraction of the species range. If these ecological vicissitudes were sudden and drastic, as in the event of a sharp drought or unusual winter, the range contraction would be sudden. Although range contraction may be sudden and drastic, it is likely that recovery and range extension is usually slow.

It is often stated that certain forms have migrated over land bridges. We believe with Simpson (1950) that species *spread* rather than *migrate* over such areas, and that they do so only if they are adapted to the ecological conditions existing on the bridge.

Origin of Atopsyche

Of the various groups of *Atopsyche*, the *tripunctata* group is by far the most primitive. It contains the species *erigia* which is in most respects exactly like the deduced, imaginary species which gave rise to the entire genus, and also many other species which differ only slightly more from this progenitor. This entire assemblage occurs only in the North American part of the range of the genus, centering around the Mexican plateau. In South America and the West Indies occur only more specialized groups of *Atopsyche*, including the most highly developed complexes in the genus, such as the *falina* group and the *bolivari* and *kamesa* complexes. This indicates that Mexico represents the primitive habitat and area of origin of *Atopsyche*, and that the genus spread subsequently to other parts of the Americas.

Analysis of other material of Hydrobiosini (the tribe to which *Atopsyche* belongs) suggests that the genus arose from a Eurasian ancestor reaching the Central American region in Late Cretaceous and becoming segregated into a North and South American segment throughout the Eocene (Ross, 1951). It is the assumption here that this North American population evolved into *Atopsyche*. Since its origin, the genus has evolved into seven distinct groups or complexes represented by existing species. This same sort of relationship among existing species is shown by many caddisfly genera known from late Eocene Baltic amber, for example in the genera *Polycentropus*, *Wormaldia*, and *Brachycentrus*. While this reasoning by comparison

is by no means conclusive, we believe it indicates that *Atopsyche* arose during the Eocene.

Geographic Correlations

It seems fairly certain that various land bridges have existed between North and South America from Eocene time to the present. While there is no agreement between various authors as to the exact timing and duration of each (Schuchert, 1935; Simpson, 1950), there is indubitable stratigraphic evidence for long periods of separation of the two continents, and certain geological and biogeographic evidence for several connections between the two continents.

After the Eocene, there is evidence for two successive partial bridges, one probably in late Oligocene and another probably in lower Miocene. There may have been others in this period. From some time in the Miocene to middle Pliocene the two continents appear to have been separated, but from this latter point to the present the two Americas appear to have been united somewhat as they are now.

The distribution of known existing species of *Atopsyche* can be explained quite satisfactorily on the basis of these postulated bridges. In addition to yet unknown living species, we do not know how many species were evolved and became extinct, or in what fashion knowledge of all these would modify our interpretation of relationships within the genus. The known forms, however, can be resolved into a clear phylogenetic pattern showing dichotomies and trichotomies illustrated in fig. 1. These branchings, together with known distribution patterns, suggest a series of population movements correlated with available land bridges as follows.

We have already suggested as a starting point the development of the ancestral *Atopsyche* species in Central America and Mexico. After the establishment of an inter-American bridge, possibly in late Oligocene, this form spread into South America. When the bridge subsided, two populations were segregated, the northern one continuing relatively unchanged, the southern one developing distinctive clasper characteristics and forming the ancestral form of the subgenus *Ventrarma*. When the inter-American bridge was again passable for *Atopsyche* (possibly in early Miocene), both forms spread across it. When the bridge was again broken, the ancestor of the *batesi* group was left in Central America and the ancestor of the *bolivari* group was isolated in South America.

The isolating factors that functioned to bring about subsequent speciation of the mainland groups are not evident from our data, except that at some later date (presumably Pliocene) two other crossings occurred between the Americas. A line of the *longipennis* group spread from South America into Mexico, where it is now represented by *japoda*. A line of the *bolivari* group also spread into Mexico, producing the two species *boneti* and *dampfi*. From our data it is impossible to say whether these occurred simultaneously or not.

Origin of the Antillean Fauna

The two Antillean species of *Atopsyche*, *batesi* on Hispaniola and *trifidus* on Puerto Rico, invite some interesting speculations. There

has been much dispute regarding the origin of the fauna of the Greater Antilles. Schuchert (1935) has suggested broad land connections between various islands of this group and Central America (especially Honduras and part of Nicaragua) from late Mesozoic through Eocene and again in Miocene. Darlington (1938) believes that random dispersal over water can account better for the fauna of the Antilles.

The known elements of *Atopsyche* offer only negative evidence regarding pre-Oligocene connections, because no ancient species of either *Atopsyche* or a more primitive related genus is known from the Antilles. It may be significant, however, that (1) the two known Antillean species of *Atopsyche* are extremely different from each other but arose from the same ancestor, that of the *batesi* group; (2) this line probably existed in Honduras in Miocene at a time when perhaps only two species of *Atopsyche* inhabited the North and Central American region; and (3) there is no evidence that any other successful colonization of the Antilles was achieved by *Atopsyche*. If an Antillean bridge was in existence, it is entirely possible that it could have been ecologically selective for only one of two species in an area, thus blocking the passage for the second one.

While we do not make the assertion that this Miocene Antillean bridge existed and was used, we feel that this case indicates the desirability of giving the proposition consideration. Doing so does not exclude the probability that many Antillean colonizations resulted from overwater accidental introductions. Rather is the invitation one to attempt to analyze data in the light of dual dispersal possibilities. Among the insects, two avenues of investigation should shed some light on this question, first the exact phylogenetic relationships of insects occurring on the Antilles, and secondly, a better idea of the fauna which occurred in Central America during different periods of geologic history.

Summary of Biogeography

The phylogeny and distribution of *Atopsyche* species suggest the following:

1. Early in their history members of the genus made crossings between North and South America on two consecutive occasions to produce the first four stems of the genus.

2. At some period after the second crossing, the *batesi* line spread to the Greater Antilles. The elapsed time between the second Panamanian crossing and the spread to the West Indies is the time that was required for the development of the curious forked dorsal process of the aedeagus in the ancestor of the *batesi* group. This is the only Antillean crossing of which we have evidence to date.

3. Considerably later a third exchange of some species occurred between North and South America.

4. It is likely that these movements correspond with land connections occurring between periods of separation of the continents. This separation would be from the standpoint of *Atopsyche* spread, and could have been caused equally well by marine transgressions (as some undoubtedly were) or by unfavorable ecological conditions.

5. For various reasons cited earlier in this paper, we are suggesting tentative time assignments as outlined in fig. 1.

TAXONOMY

The genus *Atopsyche* belongs to the tribe Hydrobiosini, and is readily separated in the adult stage from other American genera on the basis of its wide anal cells. Characters for separating it from the other genera of the world are given by Ross and King (1951). The larva of *Atopsyche* resembles that of *Rhyacophila*, but differs markedly in the chelate front legs (Hinton, 1950).

The diagnoses in this paper are based entirely on the male sex. We were able to associate the females with the respective males in only a few instances and feel that any attempt to treat this sex now would only invite gross misidentification due to inadequate analysis of characteristics.

Unless otherwise indicated, material is in the collection of the Illinois Natural History Survey. Material from other collections is indicated individually in the text.

Acknowledgement is made gratefully of the assistance rendered us by many workers, in supplying critical information or material used in this study. These are due especially to J. C. Bequaert, Museum of Comparative Zoology; Cornelius Betten, Asheville, North Carolina; Federico Bonet, Escuela Nacional de Ciencias Biologicas; Mont A. Cazier, American Museum of Natural History; D. G. Denning, Velsicol Corporation; K. J. Hayward, Fundacion Miguel Lillo; D. E. Kimmins, British Museum (Natural History); J. A. G. Rehn, Academy of Natural Sciences of Philadelphia; L. J. Stannard, Illinois Natural History Survey; Georg Ulmer, Hamburg, Germany; and G. E. Wallace, Carnegie Museum.

The species of *Atopsyche* are here grouped into two subgenera and several species groups and complexes as charted in fig. 1.

SYNOPSIS OF SUBGENERA AND GROUPS

A. Basal segment of clasper simple, fig. 6*A* ..... Subg. **Atopsyche**
B. Apical segment of clasper trianguloid ..... Gp. **tripunctata**
BB. Apical segment of clasper bean-shaped or constricted at base, ... Gp. **bolivari**
AA. Basal segment of clasper with apical projections or processes, fig. 15*A*, ... Subg. **Ventrarma**
B. Both clasper and aedeagus fairly simple, figs. 18*A*, *B* ..... Gp. **falina**
BB. Aedeagus with a curious dorsal structure forked at base, figs. 16*B*, *C* ..... Gp. **batesi**
BBB. Basal segment of clasper with its apical process paralleling apical segment, fig. 20*A* ..... Gp. **longipennis**

KEY TO SPECIES (MALES ONLY)

1. Basal segment of clasper with an apical lobe which may be dorsal, fig. 16*A*, ventral, fig. 15*H*, or mesal, fig. 20*A* 2
Basal segment of clasper simple and unexpanded at apex, fig. 3*A* 10
2(1). Aedeagus with a long dorsal process which has a Y-shaped base that articulates with the body of the aedeagus, fig. 15*B* 3
Aedeagus either without a long dorsal process or with one which is attached solidly to the body of the aedeagus, figs. 3*B*, 23*B* 5
3(2). Suture between segments of clasper obliterated, fig. 17*A* ..... **majada**
Suture separating the two clasper segments distinct 4
4(3). Basal segment of the clasper with both a dorsal and a ventral prolongation at apex, the two enclosing the base of the apical segment; filicercus present, fig. 15*A* ..... **trifida**
Basal segment of clasper with only a dorsal prolongation; filicercus lacking, fig. 16*A* ..... **batesi**

5(2). Basal segment of clasper with apical process mesal in position, either behind or parallel with apical segment, fig. 20*A* 6
Basal segment of clasper with apical process ventral, extending below apical segment, fig. 18*A* 9
6(5). Filicercus lacking, fig. 20*A* ..... **iana**
Filicercus present, fig. 23*A* 7
7(6). Basal segment of clasper narrow and elongate, about 5–6 times as long as wide, fig. 23*A* ..... **japoda**
Basal segment of clasper shorter and thicker, about three times as long as wide, fig. 22*A* 8
8(7). Aedeagus without sclerotized processes; apical clasper segment stout, angled, and boot-shaped, fig. 22*A* ..... **longipennis**
Aedeagus with two pairs of sclerotized processes on ventral side; each principal lobe with an elongate, pedunculate, spiny process, fig. 21*B*; apical clasper segment not boot-shaped ..... **hamata**
9(5). Dorsal lobe of aedeagus low and somewhat heart-shaped, fig. 18*C* .. **falina**
Dorsal lobe terminating in two strong, high, sharp spines, fig. 19*B* .. **lobosa**
10(1). Clasper with apical segment nearly as long as basal segment and narrowed at base, fig. 14*A*; aedeagus with a curious, dorsal, bilobed process, fig. 14*C* ..... **kamesa**
Clasper with apical segment either not constricted at base, fig. 3*A*, or much shorter than basal segment, fig. 10*A* 11
11(10). Basal segment of clasper with a mesal, shoulder-like projection, fig. 12*E* 12
Basal segment of clasper with no projection on mesal margin 16
12(11). Paracercus having two large, sharp, sclerotized preapical processes, fig. 12*A* ..... **ikonnikovi**
Paracercus with only one sclerotized preapical point, fig. 6*A* 13
13(12). Aedeagus very narrow, the principal lobes slender and elongate, fig. 6*C*, and without dorsal projections ..... **sperryi**
Aedeagus wide at base, fig. 9*C*, and bearing dorsal projections, fig. 9*B* ... 14
14(13). Paracercus sigmoidally curved and elevated like a swan's neck; dorsal projections of aedeagus forked, fig. 7*A* ..... **tripunctata**
Paracercus only gently curved, with a sharp preapical point; dorsal projections of aedeagus single, fig. 8*A* 15
15(14). Aedeagus with a stout, sclerotized, lateral projection, and only a slight stub remaining of the inner rod, figs. 9*B*, 9*C* ..... **aplita**
Aedeagus without a lateral process but with a well-developed inner rod, fig. 8*C* ..... **cira**
16(11). Clasper with apical margin trianguloid, wide at base and tapering to apex, figs. 6*A*, 7*A* 17
Clasper bean-shaped, curved, and narrowed near middle, fig. 10*A* 19
17(16). Aedeagus without sclerotized processes on base or on principal lobes, fig. 3*C* ..... **erigia**
Aedeagus with some sclerotized ornamentation 18
18(17). Aedeagus cleaver-shaped in profile, with two pairs of short, sclerotized processes near tip of each principal lobe, fig. 4*B* ..... **espala**
Aedeagus trapezoidal in profile, a single sclerotized process arising from the base of each principal lobe ..... **calopta**
19(16). Filicercus lacking; paracercus elongate and filiform, terminating in a clump of heavy setae, figs. 13*A*, 13*F* ..... **bolivari**
Filicercus present; paracercus with at least two high, strongly sclerotized teeth at the center or basad of the center, fig. 11*A* 20
20(19). Aedeagus with two pairs of elongate lateral processes in addition to the principal lobes, fig. 11*C* ..... **dampfi**
Aedeagus with only short lateral processes in addition to the principal lobes, fig. 10*C* ..... **boneti**

Subgenus **Atopsyche** Banks

Atopsyche Banks, 1905, Trans. Amer. Ent. Soc., 32: 17. Genotype: *Atopsyche tripunctata* Banks. Orig. desig.
Atopsychodes Mosely, 1949, Proc. R. Ent. Soc. London (B), 18: 37. Genotype: *Atopsychodes cira* Mosely. Orig. desig.

The genus *Atopsychodes* was erected by Mosely chiefly on the basis of the long, lateral filament of the male fifth abdominal segment. This structure proves to vary indiscriminately in various lines of the genus and to be unusable as a group character of phylogenetic significance. On the basis of other characters it is clear that *cira*, the genotype of *Atopsychodes*, belongs to the same small complex of species containing *tripunctata*, the genotype of *Atopsyche*. Hence the name *Atopsychodes* is placed as a synonym.

The **tripunctata** group

This group has a single type of clasper with the basal segment simple and the apical segment trianguloid, fig. 7*A*. It is the most primitive group in the genus. Its deduced ancestor possessed this simple clasper in combination with a simple aedeagus, both exemplified by *erigia*, fig. 3*A*. The other six species appear to form a pectinate branch of small complexes. The ancestor of this branch developed an in-rolled upper margin on the apical segment of the clasper, giving rise first to the *espala-calopta* complex having a simple basal segment and a short, spurred aedeagus, and to the *sperryi* complex having a simple aedeagus but a mesal shoulder on the basal segment of the clasper. The remaining three species form the *tripunctata* complex, sharing in common a narrow apical clasper segment which is usually curved mesad, a mesal shoulder on the basal clasper segment, and a pair of dorsal processes near the apex of the aedeagus. The mesal shoulder suggests a relationship with the *sperryi* line. If this is correct, then the in-rolled apical clasper segment of that species was the forerunner of the narrower and slightly twisted apical segment in the *tripunctata* complex.

Atopsyche erigia Ross

Atopsyche erigia Ross, 1947, Trans. Amer. Ent. Soc., 73: 129, fig. 5.

Male genitalia as in fig. 3. Paracercus about four times as long as its greatest width, setose at apex, with two poorly developed dorsal teeth. Filicercus stout and somewhat clavate, with several strong setae on its apical third. Clasper segments simple: the basal, cylindrical; the apical, conical. Aedeagus simple, the principal lobes bluntly rounded at their apices. Inner rod present; no other ornamentation.

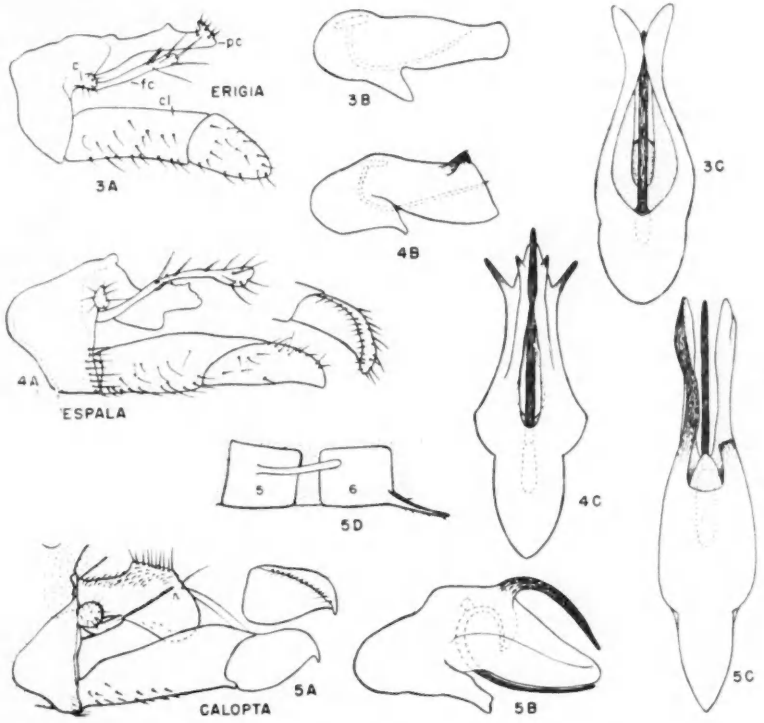
Type series: Tamaulipas, Mexico, Hacienda Santa Engrecia, March 9, 1939, H. Hoogstraal.

This is one of the more common species of the genus in Mexico. In addition to the type series, the following specimens have been studied, all from Mexico, and collected by A. Dampf. CHIAPAS: Finca Esperanza, Feb. 6 to Sept. 7, 17♂; Copainala, Sept. 5, 1♂. TAMAULIPAS: Santa Engracia, Feb. 13 to Mar. 22, 6♂. JALISCO: La Barca, Oct. 3, 1♂. OAXACA: Valle Nacional, Mar. 2, 1♂. No data, 3♂.

Atopsyche calopta new species

Male.—Length, 11 mm. Wing, 8.5 mm. General body color and structure typical for the genus. Genitalia as in fig. 5. Paracercus twice as long as its greatest width, edentate, its apex rounded; entire dorsal surface covered with fine setae; a line of strong setae along a raised dorsal ridge. Filicercus little longer than side piece and bearing

at its tip a strong, elongate seta. Basal clasper segment irregular in shape, slightly conical, expanding apically. Apical segment with an oblique setose ridge on mesal aspect from its proximo-dorsal corner to the slightly hooked apex. Aedeagus narrow and deep, the principal lobes making up the apical half and tapering abruptly to a blunt point. Inner rod present. Dorsum of the basal portion of each of the principal lobes bearing a sclerotized projection which arches caudad nearly to the tips of the lobes.



FIGS. 3–5. Male genitalia of *Atopsyche* s.s. *A*, lateral aspect; *B*, *C*, aedeagus, lateral and dorsal aspects; *D*, lateral aspect of 5th and 6th abdominal sternites. *c*, cercus; *cl*, clasper; *fc*, filicercus; *pc*, paracercus.

Holotype.—Male; Cuernavaca, Morelos, Mexico, March 2, 1932, at light, A. Dampf.

Paratypes.—All from Mexico. MORELOS—Cuernavaca: April 8–11, 1932, 2♂, C. C. Plummer; March 7–8, 1932, 1♂, March 26–29, 1932, 3♂, March 2, 1932, 1♂, A. Dampf. OAXACA—Yagila: Feb. 26, 1932, 1♂. Tepanzocoalco: Feb. 24, 1932, 3♂, A. Dampf. CHIAPAS—San Cristobal: June 21, 1926, 1♂, A. Dampf. "MEXICO, A. Dampf," 3♂. All the above specimens were taken at light.

Atopsyche espala new species

Male.—Length, 7 mm. Wing, 5.5 mm. Color and general structure typical for genus. Genitalia as in fig. 4. Paracercus irregular, deeply notched ventrally and bearing a simple sclerotized tooth dorsally at its apical third. Filicercus elongate, ending in a truncate club and sparsely setose over its apical three-fifths. Basal clasper segment very obliquely truncate apically on its outer aspect; less so on its inner. Inner surface of apical segment obliquely ridged as in *calopta*, the dorsal margin appearing as though inrolled. Aedeagus with principal lobes cleaver-shaped in profile, each bearing near its tip two stout, sclerotized projections, the more lateral of which is the longer. Inner rod present and complete.

Holotype.—Male; Tecpatan, Chiapas, Mexico, Sept. 1, 1946, at light, A. Dampf.

Atopsyche sperryi Denning

Atopsyche sperryi Denning, 1949, Jour. Kans. Ent. Soc., 22: 88, fig. 1.

Male.—Genitalia as in fig. 6. Paracercus large, rounded apically, a blunt projection at the midpoint of the dorsal margin, and another near its base. Filicercus short and curved, setiferous on its apical half. Basal clasper segment with a prominent finger-like projection and shelf on its mesal side; apical segment conical, slightly hooked at tip, with an oblique setose ridge on the inner side from base to apex. Aedeagus narrow, simple, nearly five times as long as deep.

This species is known only from the holotype, collected at ARIZONA: Oak Creek Canyon, Todd's Lodge, Sept. 26, 1948, Grace H. and John L. Sperry.

Dr. Denning kindly loaned us this specimen for study.

Atopsyche tripunctata Banks

Atopsyche tripunctata Banks, 1905, Trans. Amer. Ent. Soc., 32: 17–18.
Atopsyche tripunctata Banks. Ross, 1947, Trans. Amer. Ent. Soc., 73: 128, fig. 3.

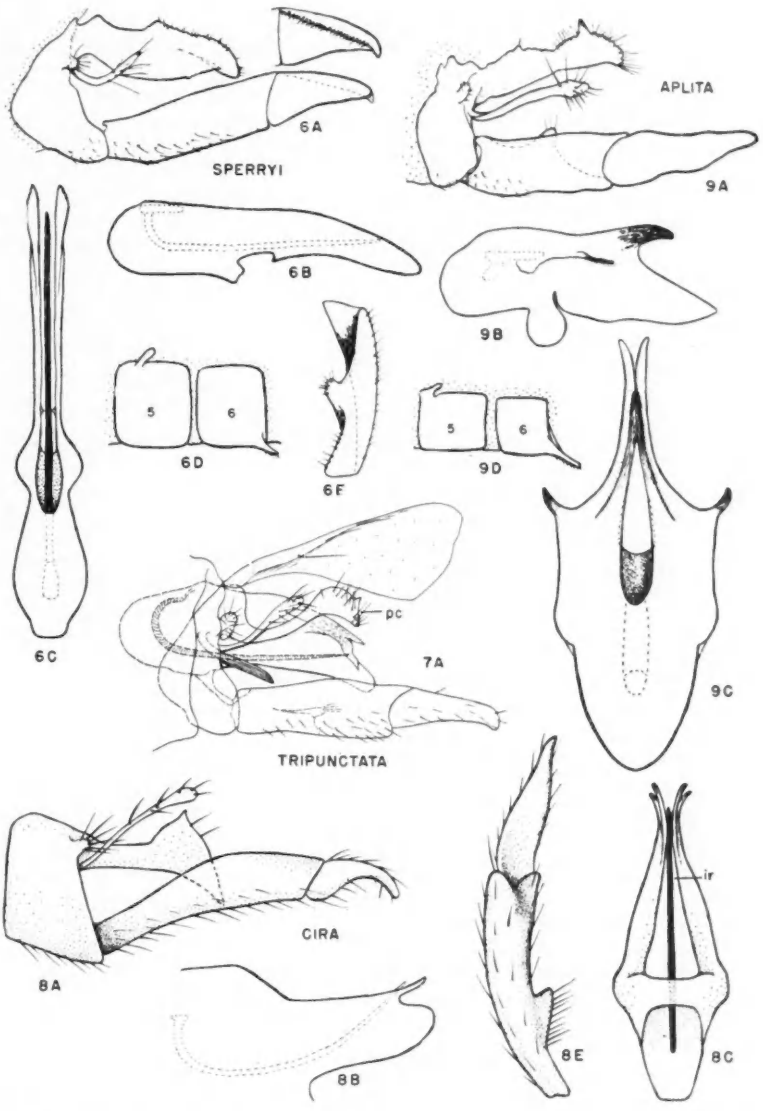
Male.—Genitalia as in fig. 7. Paracercus elongate, little larger than the filicercus except at its apex. Filicercus shorter than the paracercus, clavate, setiferous on its apical third. Clasper with basal segment provided with a prominent inner shelf having a setiferous fingerlike projection; apical segment simple, elongate, conical. Aedeagus elongate, bluntly pointed at tip, with two pairs of sclerotized processes: a lateral one near the base, and a dorsal one near the apex, the latter fused for part of its length to produce a single, forked projection. Inner rod present.

In addition to the record from Ross, 1947, of two specimens collected by H. Skinner in August, 1905, one bearing the data "Huachuca Mts., Arizona," and the other from "Carr Canyon, Huachuca Mts., Cochise Co., Arizona," an additional record is noted of larvae and mature pupae, with the following data: "Arizona, Cochise Co., Huachuca Mts., 7200', Carr Canyon, July 30, 1947, H. K. Gloyd and Wm. M. Clay."

Atopsyche cira (Mosely)

Atopsychodes cira Mosely, 1949, Proc. Roy. Ent. Soc. London, 18 37–39, figs. 1–7.

The presence of a pair of stout lateral filaments on the fifth



FIGS. 6–9. Male genitalia of *Atopsyche* s.s. *A*, lateral aspect; *B*, *C*, aedeagus, lateral and dorsal aspects; *D*, lateral aspect of 5th and 6th abdominal sternites; *E*, ventral aspect of basal clasper segment; (Figs. 8*A*, *B*, *C*, *E* redrawn from Moseley). *ir*, inner rod.

abdominal segment—the primary character on which Mosely established the genus *Atopsychodes*—is now known to occur in more than half of the species of *Atopsyche*. All degrees of development of these filaments are shown, from small, buttonlike protuberances in *falina* to long processes in *cira* and *trifida*.

Atopsyche cira appears to be more closely related to *A. tripunctata* than to any other known species. Clasper and filicercus are very similar, and though Mosely's drawing of the aedeagus does not show great detail, a relationship to *tripunctata* is not contradicted by it. The paracercus ("hammer-head" of Mosely) resembles that of *tripunctata* in its generally sigmoid curvature, but is more produced both apically and dorsally.

Type locality: Costa Rica. Type ♂ collected at Trazu, 6–7000 ft., by H. Rogers, and in the collection of the British Museum; Paratypes ♂ and ♀, Irazu, 2200–2500 m., May 21–28, 1930, Reimosa, are in the collections of the Vienna Museum.

Atopsyche aplita new species

Male.—Length, 13 mm. Wing, 11.5 mm. Color and form typical for the genus. Genitalia as in fig. 9. Paracercus three times as long as its widest part, with ventral edge unevenly sinuate. Its dorsal edge crenulate, with a strong tooth at the apical fourth and an elevated region at the basal third; these separated by a depression. Filicercus three-fourths the length of the paracercus, slightly clavate; the setae confined to the clavate portion. Basal clasper segment with a pronounced shelf on its inner aspect; the apical segment elongate, conical, as long as the basal. Aedeagus wide and deep, the principal lobes tapering rather abruptly to a pointed apex. Two pairs of sclerotized processes present: a dorsal pair short and arching, and a lateral pair cornuate, figs. 9*B*, 9C. Inner rod, except at its base, lacking in the single specimen available.

Holotype.—Male; Rio Frio, Mexico, April 2, 1947, elev. 2900–3000 meters, at light, A. Dampf.

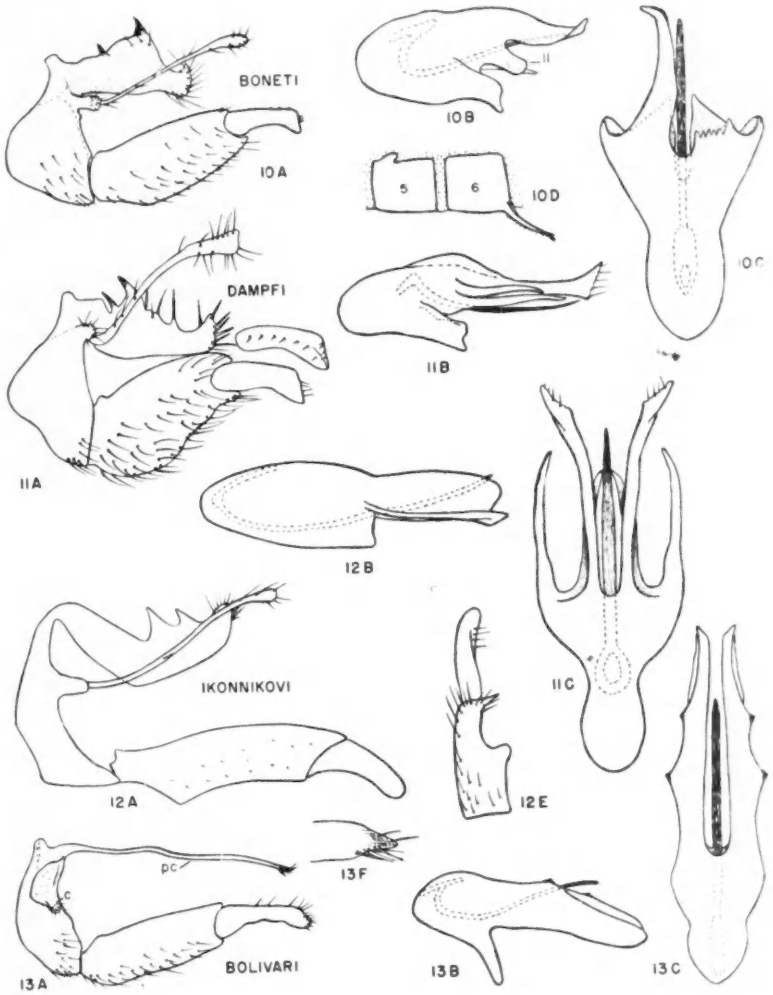
The **bolivari** group

This group is characterized primarily by a constricted condition of the apical segment of the clasper. It contains three very distinct subgroups, the *bolivari*, *ikonnikovi*, and *kamesa* complexes.

The **ikonnikovi** complex

In *ikonnikovi*, *boneti*, and *dampfi*—the species so far known in the *ikonnikovi* complex—the paracercus is large and bears dorsally two or three high, sharp spines. The aedeagus is broad and possesses one or two pairs of nonsclerotized projections not shown by other members of the genus. The filicercus is elongate, and all three have at least a slight indication of a shelf on the basal clasper segment, apparently developed in parallel with the *tripunctata* group.

If one considers the divergence of the three species within the *ikonnikovi* complex, *boneti* appears to be the most primitive. Its aedeagus, fig. 10C, shows well developed the principal lobes characteristic of all the *Atopsyche* species. Ventrally the aedeagus of *boneti* has two



FIGS. 10–13. Male genitalia of *Atopsyche* s.s. *A*, lateral aspect; *B*, *C*, aedeagus, lateral and dorsal aspects; *D*, lateral aspect of 5th and 6th abdominal sternites; *E*, ventral aspect of basal clasper segment; *F*, tip of paracercus; (Figs. 12 *A*, *B*, *E* redrawn from Martynov). *ll*, lateral lobes.

small triangular lobes and laterally it has a pair of short, spoon-shaped ones. From the presumed ancestor of ***boneti*** must have come a form such as ***dampfi***, in which the ventral and lateral non-sclerotized processes of the aedeagus attained considerable length, fig. 11*C*. Specimens of ***ikonnikovi*** Martynov were not examined, and the figures illustrating the species, figs. 12*A*, *B*, *E*, were redrawn from those in the original description. From these it appears that ***ikonnikovi*** must have had an origin previous to that of ***dampfi***, since Martynov illustrates but one pair of elongate structures in addition to the principal lobes. It is not clear whether these are the lateral or the ventral, but the point is immaterial here. The fact remains that one of the two pairs foreshadowed by ***boneti*** and possessed by ***dampfi*** did not develop in ***ikonnikovi***.

Atopsyche boneti new species

This species somewhat resembles ***ikonnikovi*** Mart., but differs in the form of the appendages of the aedeagus.

Male.—Length, 8 mm. Wing, 7 mm. External characteristics typical of the genus. Genitalia as in fig. 10. Paracercus large, with a strong, highly elevated, medio-dorsal tooth and a smaller tooth at the basal third. Apex setiferous and somewhat hooked. Filicercus longer than the paracercus, slender, clavate, and setiferous along its entire length. Clasper with basal segment inflated; the apical constricted at center and truncate apically. Aedeagus broadly flaring at center; the principal lobes short, about one-third the length of the organ. Inner rod present and complete. Aedeagus provided with a pair of short, wide, triangular projections ventrally and with another pair of broad, cup-shaped projections at the extremes of the lateral expansions.

Holotype.—Male; Cuernavaca, Morelos, Mexico, March 18, 1932, at light, C. C. Plummer.

Paratypes.—All from Mexico. MORELOS—Cuernavaca: March 2, 1932, 3♂; March 23, 1932, 1♂; March 26–29, 1932, 1♂. All at light, collected by C. C. Plummer.

Atopsyche dampfi new species

Atopsyche dampfi differs from ***boneti*** and ***ikonnikovi*** primarily in details of the structure of the aedeagus.

Male.—Length, 7.5 mm. Wing, 6.5 mm. External characteristics those of the genus. Genitalia as in fig. 11. The external terminal appendages of this species differ only slightly from those of ***boneti***. Paracercus with two strong teeth dorsally and one or more setiferous dorsal tubercles on the apical half. Filicercus as in ***boneti***. Clasper with basal segment bulky, swollen, its tip indented for the insertion of the apical segment; the latter constricted at its center and truncate apically. Aedeagus broad at its center, the general shape as in ***boneti***. Sclerotized processes lacking. Inner rods present. Two pairs of narrow, elongate processes present, their origin and position lateral and ventral to the principal lobes.

Holotype.—Male; Finca Vergel, Chiapas, Mexico, June 10, 1935, at light, A. Dampf.

Paratypes.—All from Mexico, collected at light by A. Dampf. CHIAPAS—Finca Victoria: June 2, 1935, 2♂. Finca Esperanza:

June 16–26, 1938, 2♂; April 23–30, 1939, 1♂. Finca Vergel: same data as holotype, 2♂; May 9-June 7, 1935, 2♂. OAXACA—Orilla del Rio, Jalatlaco: July 21, 1941, 1♂. Yagilla, Yxtlan, November 5, 1935, 1♂. VERA CRUZ—Cosatlan: July, 1932, 1♂. "MEXICO"—No other data, 1♂.

Atopsyche ikonnikovi Martynov

Atopsyche ikonnikovi Martynov, 1912, Ann. Mus. Zool. Ac. Sci., 17: 34, figs. 54–59.
Atopsyche Ikonnikovi Martynov. Ulmer, 1913, Deutsch. Ent. Zeit., 4: 384.

The **bolivari** complex

Atopsyche bolivari is a bizarre species, quite unlike any other in the genus, fig. 13*A*. While its characteristics of the clasper place it with little doubt on the line which gave rise to the *ikonnikovi* complex, its relatively simple aedeagus indicates its divergence before the development of the type of aedeagus shown in *boneti*, fig. 10*B*. When one notes, in addition, the complete loss of the filicercus and the extraordinary elongation of the paracercus, its inclusion in the *ikonnikovi* complex appears impossible, and it must be assumed that *bolivari* diverged early from the *ikonnikovi* stem and in its own evolution underwent striking change.

Atopsyche bolivari Banks

Atopsyche bolivari Banks, 1924, Bull. Mus. Comp. Zool., 65: 443.

A. bolivari is a species which at present seems to stand alone in the genus. The shape of the clasper, fig. 13*A*, drawn from the type, appears to relate it to the species of the preceding group, but the lack of processes on the aedeagus, the extremely elongate paracercus, and the loss of the filicercus all indicate considerable divergence from any other known species in the genus.

Type locality: Colombia. The holotype male is in the Museum of Comparative Zoology, with the following data: Colombia: Tolima, Monte Socorro, Tochecito Quindini (Edvard Fassl).

The **kamesa** complex

Atopsyche kamesa, the only known species in the complex, is allied to the *ikonnikovi* complex as evidenced by its elongate and somewhat constricted apical clasper segment, fig. 14*A*, as well as by its inflated basal clasper segment. Structures of the aedeagus, filicercus, and paracercus preclude placing it directly with such forms as *dampfi* and *boneti*, and it cannot be placed in close relationship to *bolivari* for the same reason.

The paracercus of *kamesa* is relatively elongate, but not the exaggerated filiform type of *bolivari*. It lacks the high median teeth characteristic of the *boneti* complex.

The filicercus is relatively short, and resembles that of *sperryi* or *erigia*. If the latter species are presumed to be primitive, then in this respect *kamesa* is less specialized than is *bolivari*, which has lost the filicercus, or than any species of the *boneti* group, in which it has become elongate.

The aedeagus of *kamesa* is unique in the genus, and its homologies are by no means certain. Its distinctive features are its extremely

short basal (anterior) region, its high dorsal crest, and its broad lateral vertical flanges, which lie *laterad* of the paracerci. No other aedeagus in the genus possesses such flanges, but it may be noted that the closest approach to them is in the aedeagi of the *boneti* complex, especially in the aedeagus of *A. boneti*, which has acquired the necessary width and whose lateral lobes, fig. 10 *B*, *C*, could have expanded to produce the flanges of *kamesa*.

Atopsyche kamesa n. sp.

Male.—Length, 12 mm. Wing, 11 mm. External characteristics those of the genus. Genitalia as in fig. 14. Paracercus with a single apico-dorsal tooth; its base straight. Filicercus shorter than that of *tripunctata*, clavate, densely setiferous at tip. Basal clasper segment cylindrical, with short, acutely pointed inner shelf at midpoint. Apical segment nearly as long as basal, somewhat spatulate, and ventrally curbed at base. Aedeagus differing from all other known members of the genus in possessing a pair of high lateral vertical flanges, which, when the aedeagus is in normal position, lie lateral to the paracerci. The aedeagus also is surmounted by a high crest, which narrows posteriorly and bifurcates into two somewhat depressed lobes. Principal lobes broad, spatulate, fleshy; without sclerotization. Principal lobes and the flanges mentioned above making up nearly the entire length of the aedeagus; *i.e.* bulbous basal portion much shorter than in any other species. Inner rod present.

Holotype.—Male; Incachaca, Bolivia, no date, 8100 ft., J. Steinbach. In the collection of the Carnegie Museum.

Subgenus **Ventrarma** Navas

Ventrarma Navas, 1924, Broteria, Serie Zoologica, 21: 76.
Genotype: *Ventrarma implexa* Navas. Orig. desig.

It has been noted that an early branch of the ancestral Atopsyche form gave rise to a specialized division of the genus in which the basal clasper segment shows a fingerlike prolongation at its apical end. This prolongation takes one of three positions: it is either dorsal or ventral to the apical segment, as in *majada*, fig. 17*A*, or it is mesal to the apical segment at its base and may lie mesal to the apical segment for its entire length. The latter condition is illustrated by *iana*, fig. 20*A*.

The **batesi** group

Four species are included here: *batesi*, *trifida*, *implexa* and *majada*. We have seen no specimens of *implexa*, so that although we can place it to group on characters illustrated in the original description, we are unable to discuss its placement beyond that. All species studied have in common a dorsal rod attached to the aedeagus. This organ appears to be not homologous to any structure seen elsewhere in the genus. It is unpaired, curved and bifurcate at its base, and attached loosely to the sides of the aedeagus only by its two basal arms. The phylogeny of the three species is perhaps as follows. The original prototype possessed only a ventral projection of the basal clasper segment, probably similar to that in *falina*, fig. 18. *Majada*, fig. 17*A*, lost the suture separating the two segments but retained the ventral elongation. In

trifida, fig. 15*H*, the basal clasper segment developed a dorsal as well as a ventral projection at the apex. In *batesi*, fig. 16*A*, this trend was continued to an extreme condition, with the great prolongation of the dorsal process and the loss of the ventral process. If this is true, it would indicate a shift in selection pressure in the *batesi* line from utility of the ventral process to increased utility of the dorsal process; it is then perhaps not a coincidence that this apparently occurred parallel with the complete loss of the filicercus, which when present is situated just dorsad of the claspers.

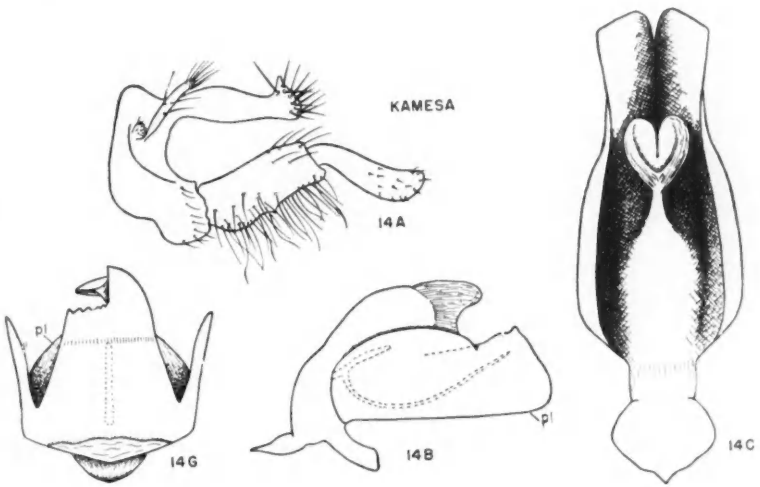


FIG. 14. Male genitalia of *Atopsyche kamesa* n. sp. *A*, lateral aspect; *B*, *C*, aedeagus, lateral and dorsal aspects; *D*, anterior aspect of aedeagus. *pl*, principal lobe.

Atopsyche implexa (Navas)

Ventrarma implexa Navas, 1924, Broteria, Serie Zoologica, 21: 77, fig. 14.
Atopsyche implexa Navas. Ross, 1947, Trans. Amer. Ent. Soc., 73: 127–128.

Specimens of this species were not examined, but it is described and illustrated by Navas as having a ventral prolongation of the basal clasper segment arising from the midpoint of that segment. If it possesses a dorsal prolongation also, it would probably be correctly placed in the *batesi* group, near *majada*.

Type locality: Costa Rica.

Atopsyche majada Ross

Atopsyche majada Ross, 1947, Trans. Amer. Ent. Soc., 73: 129, fig. 4.

The male genitalia are shown in fig. 17, and it will be noted that in this species the suture between the two clasper segments has been entirely obliterated. For reasons expressed elsewhere in this paper,

it is believed that the dorsal lobe of the definitive clasper represents the original apical segment. The dorsal rod is prominent, high, and straight; the aedeagus broad and fleshy.

This species was described from a single specimen collected by H. Hoogstraal in moist jungle at La Majada, Apatzingan, Michoacan, Mexico, August 12, 1941. It is by far the most numerous species in the Dampf collection, and the following additional records from Mexico are given below.

CHIAPAS.—Finca Cuahtemoc: August 3–13, 1950, C. J. Goodnight, 1♂. Finca Esperanza: April 26-September 22, 1938, 54♂; March 13-June 10, 1939, 7♂. Finca Vergel: May 11-June 6, 1935, 30♂. Finca Victoria: June 2, 1935, 1♂; May 16, 1938, 1♂. San Cristobal: Dec. 13, 1937, 2♂. MORELOS.—Cuernavaca: Feb. 23-March 29, 1932, 6♂. Cuautla: Sept. 23, 1937, 1♂, A. Dampf. VERA CRUZ.—Cosatlan: July 1932, 1♂, collected by A. Dampf. "MEXICO".—2♂, A. Dampf.

Atopsyche trifida Denning

Atopsyche trifidus Denning, 1948, Canad. Ent., 80: 113, fig. 22.

The male terminal structures of *A. trifida* are illustrated in figs. 15*A*, *B*, *C*, *H*. The basal clasper segment is unique in the genus in having both a dorsal and a ventral apical projection. The aedeagus is also distinctive.

This species is known only from the holotype male, collected in a light trap at Luquilla, Puerto Rico, October 29, 1943, by H. D. Pratt. This specimen was loaned to us by Dr. Denning.

Atopsyche batesi Banks

Atopsyche batesi Banks, 1938, Rev. Ent. Rio de Janeiro, 9: 304, fig. 29.

Male terminal structures of *batesi*, redrawn from the type, are illustrated in figs. 16*A*, *B*, *C*. Noteworthy features of this species are, besides those which mark the group, the partial disappearance of the suture between the two clasper segments, the loss of the filicercus, and the absence of any ventral prolongation of the basal clasper segment.

Type locality: Haiti. The holotype was collected at La Vesite, La Selle Range, Haiti, 16–23 Sept., by M. Bates.

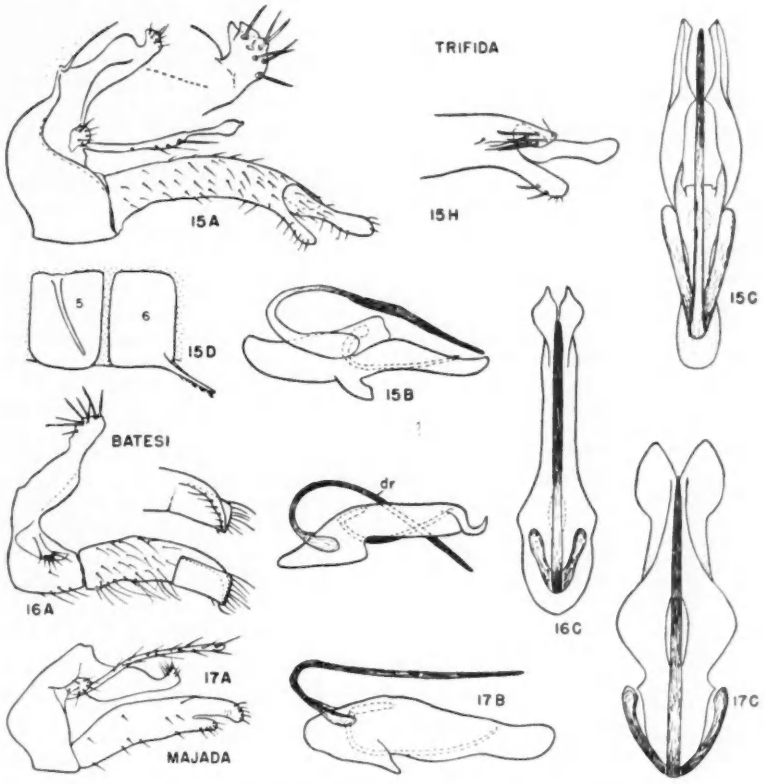
The **falina** group

Atopsyche falina and *lobosa*, figs. 18, 19, appear to be quite unlike the other species which have an apical ventral process on the basal clasper segment. Their most distinctive features are their ventral clasper process and their lack of the dorsal rod. These two characteristics serve to place them chose to, but not in, the preceding group. The two also show a specialization not found elsewhere: a fleshy, bilobed, recurved process on the dorsum of the aedeagus in *falina*, and in *lobosa* the same structure has become a strong, nearly vertical, bifurcate process.

Atopsyche falina new species

Male.—Length, 10 mm. Wing, 9 mm. General external appearance typical for the genus. Genitalia as in fig. 18. Paracercus elongate, narrow to midpoint, thence deepening abruptly to form a single dorsal

tooth and tapering again before forming a smaller apical one. Ventral edge smoothly curved. Filicercus longer than paracercus, slender, setiferous along its entire length. Clasper with basal segment irregularly curved, thickest at center, and with a fingerlike prolongation ventrally at the apex. Apical segment short, subtriangular in outline. Aedeagus narrow at base; the apical two-thirds consisting of the broad and



FIGS. 15–17. Male genitalia of *Atopsyche* subg. *Ventrarma*. *A*, lateral aspect; *B*, *C*, aedeagus, lateral and dorsal aspects; *D*, lateral aspect of 5th and 6th abdominal sternites; *H*, mesal aspect of clasper. *dr*, dorsal rod.

fleshy principal lobes, which are bluntly rounded at their tips. No sclerotized ornamentation. Dorsal rod present. This species unique in the possession of a recurved, cordiform, tuberculate process arising dorsally at the basal two-fifths of the aedeagus and curving upward and basad a little less than its own length.

Holotype.—Male; Tafi del Valle, Tucuman, Argentina, elev. 2000 meters, December 10, 1942, collector Golbach. In the collection of the Institute of Entomology, National University of Tucuman.

Atopsyche lobosa n. sp.

This species differs from *falina* only in degree, and there seems little doubt that the two are closely allied.

Male.—Length, 11 mm. Wing, 10 mm. External characteristics those of the genus. Genitalia illustrated in fig. 19. Paracercus with a high, strong dorsal tooth and its apex prolonged, depressed, and rolled outward and laterodorsad; the whole roughly resembling one-half of the tail assemblage of an airplane. Filicercus elongate, sinuate, strongly clavate. Basal clasper segment elongate, irregular beneath, its tip prolonged ventrally. Apical segment short, curved, and truncate. Aedeagus with bulbous base and principal lobes as in *falina*. Recurved, cordiform dorsal process of *falina* appearing in *lobosa* as a high, sharply pointed bifurcate process, weakly sclerotized at its base and progressively more strongly sclerotized toward the tips. Inner rod present.

Holotype.—Male; Incachaca, Bolivia, no date, 8100 ft., J. Steinbach. In the collection of the Carnegie Museum.

The **longipennis** group

The four remaining species of the genus all appear to be derived from an ancestor in which the ventral process of the basal clasper segment took a mesal position. The species in this group are *longipennis*, *iana*, *hamata*, and *japoda*. The ancestral form from which these four species probably arose must have resembled *hamata*, fig. 21*A*, in everything except its aedeagus. Phylogenetic placement of the other three species is not a simple matter. The fact that the clasper of *iana*, fig. 20*A*, is almost identical with that of *hamata* and the similarity of the paracercus of the two species are two strong points for assigning them a common origin, and the loss of the filicercus in *iana* and the striking differences in their aedeagi indicate that they must have diverged from each other comparatively early. *Longipennis* and *japoda* do not appear to be closely related, though both must have been derived from a *hamata*-like ancestor with a more generalized aedeagus than *hamata* now shows. They have in common a reduced filicercus and little else, as illustrated in figs. 22 and 23.

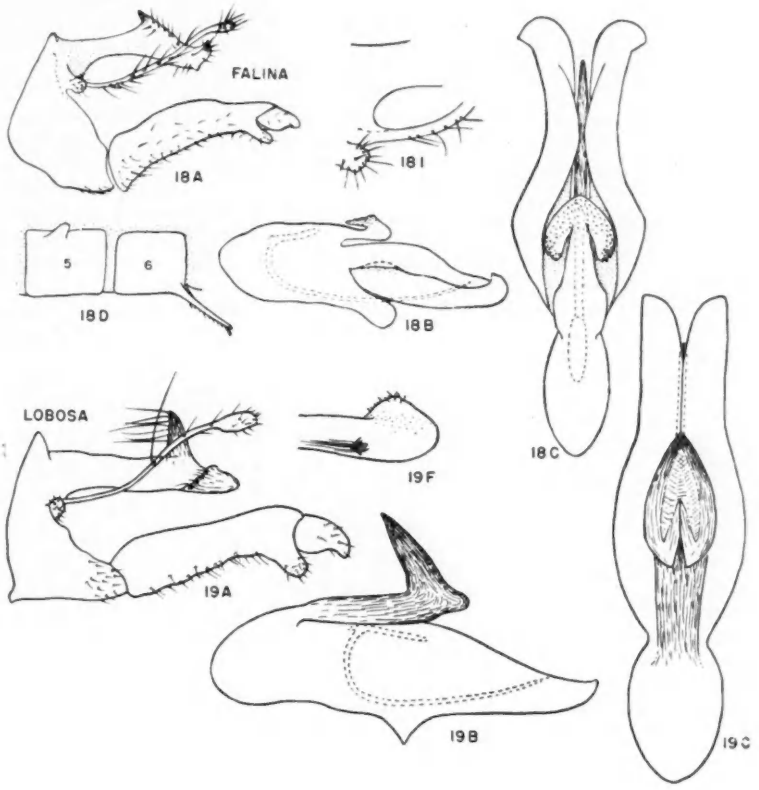
Atopsyche iana Mosely

Atopsyche spinosa Mosely, 1931, Trans. Ent. Soc. London, 79: 545, figs. 1–5.
Atopsyche iana Mosely, 1949, Roy. Ent. Soc. London (B) 18:40.

Mr. D. E. Kimmins, of the British Museum, reexamined the type of this species and supplied information, fig. 20*H*, which appears to indicate that a specimen from the summit of Mt. Roraima, Brazil is *iana*. The following description will serve to supplement Moseley's original one. The genitalia of the Brazil specimen are illustrated in fig. 20.

Male.—Length, 9.5 mm. Wing, 8.5 mm. Form and coloration characteristic of the genus. Genitalia illustrated in fig. 20. Paracercus with a strong dorsal tooth at the apical third, the ventral margin indented at the midpoint to form a more slender neck, terminating in a small dorsal tooth. Filicercus lacking. Clasper with the basal segment as in H; the apical segment slightly narrower and more curved, exposing

from the side the median projection of the basal. Aedeagus elongate, slender, the two principal lobes each bearing three sclerotized projections located as follows: the longest arising dorsally at the apical fifth, slightly curved mesad, and pointing dorso-caudad at an angle of about 20° to the horizontal plane of the aedeagus; the second slightly shorter than the first, arising near the tip, and extending somewhat laterally and



FIGS. 18–19. Male genitalia of *Atopsyche* subg. *Ventrarma*. *A*, lateral aspect; *B*, *C*, aedeagus, lateral and dorsal aspects; *D*, lateral aspect of 5th and 6th abdominal sternites; *F*, tip of paracercus; *I*, base of filicercus.

nearly perpendicular to the horizontal plane of the aedeagus; the third shorter than the second and when viewed laterally, parallel to it, arising from the extreme apex of the principal lobe and curving mesad so as to be concealed from above by the first. Inner rod present.

The holotype of this species was collected by A. Mackie at Kaieteur, British Guiana, May 26, 1929. It and a male paratype, together with

another specimen whose sex was unknown to Moseley, are in the British Museum. A single male specimen, collector unknown, is in the collection of the American Museum, bearing the data: "Summit of Mt. Roraima, Brazil; 8600'; November, 1927."

Atopsyche hamata new species

Male.—Length, 9 mm. Wing, 8 mm. Color and form typical for the genus. Genitalia illustrated in fig. 21. Paracercus simple, widest at center, a single small dorsal tooth near the tip. Filicercus sinuate, nearly as long as paracercus. Clasper with basal segment cylindrical, curved, its apex prolonged medially into a fingerlike tip. Apical segment as long as, and completely overlapping, the prolongation of the basal. Principal lobes each bearing on its caudo-ventral angle a short, strongly sclerotized spine and on its caudo-dorsal angle a long petiolate unsclerotized process. This process more than one-third the length of the entire aedeagus, bearing ventrally at its base a short spine resembling and perpendicular to that borne ventrally on the principal lobe. Smaller spines and hairs on the apical third of the process. Inner rod present, L-shaped.

Holotype.—Male; Summit of Mt. Roraima, Brazil, 8600', November, 1927, collector unknown. In the collection of the American Museum of Natural History.

Paratypes.—Same data as holotype, 2♂.

Atopsyche longipennis (Ulmer)

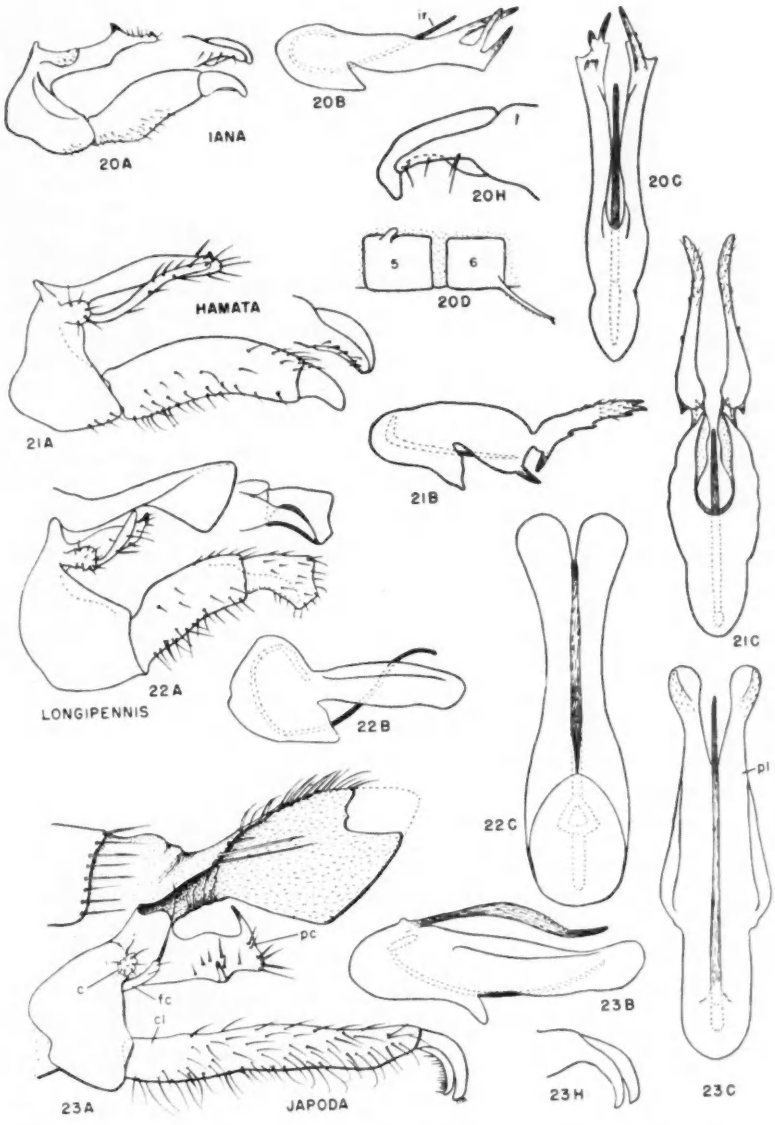
Psilochorema longipenne Ulmer, 1905, Stettiner Ent. Zeit., 66: 110, figs. 144–146.
Atopsyche brasiliana Ulmer, 1909, Ztschr. fur Insekt.-Biol., 5: 73.
Atopsyche longipennis (Ulmer). Ulmer, 1913, Deut. Ent. Zeit., 4: 384, fig. 1, 2; Ross, 1947, Trans. Amer. Ent. Soc., 73: 128.

The essential features of this species, redrawn from the type, are illustrated in figs. 22*A*, *B*, *C*. Similarities to *hamata* in the clasper, paracercus, and filicercus serve to place it with little doubt in this group. Its most distinctive features are a relatively simple aedeagus, with its extremely elongate, sigmoid inner rod, and the blunt, boot-shaped apical segment of the clasper.

Type locality: Brazil. Ulmer (1913) also records this species from Panama, Bolivia, and Chile, but we have seen no material of the species except a type specimen from Santa Catherina kindly loaned to us by Dr. Ulmer.

Atopsyche japoda new species

Male.—Length, 8.5 mm. Wing, 7.5 mm. Form and color typical for the genus. Genitalia illustrated in fig. 23. Paracercus large, deep, and somewhat rectangular in profile, with a high dorsal tooth and one arising from the lower margin at the apical third and extending latero-dorsad. Apex setiferous. Filicercus short, curved, bearing a long seta at its tip. Clasper with basal segment very slender and elongate, nearly six times as long as wide and with a hook-like median projection at its apex. Apical segment curved and much resembling the prolongation found on the basal, the two together superficially



FIGS. 20–23. Male genitalia of *Atopsyche* subg. *Ventrarma*. *A*, lateral aspect; *B*, *C*, aedeagus, lateral and dorsal aspects; *D*, lateral aspect of 5th and 6th abdominal sternites; *H*, mesal aspect of clasper; *c*, cercus; *cl*, clasper; *fc*, filicercus; *ir*, inner rod; *pc*, paracercus; *pl*, principal lobe.

looking like a pair of claws. Aedeagus simple, the principal lobes cupshaped and setiferous at their apices. A prominent, unpaired (perhaps fused) sclerotized, ensiform process arising dorsally at the basal fifth of the aedeagus, and lying dorsal to the lobes for its entire length. Inner rod present.

Holotype.—Male; "Mexico," A. Dampf.

Unplaced species

Three described species apparently belonging to *Atopsyche* are not treated in the preceding pages. Due to inaccessibility of types and inability to be sure of critical characters in the original descriptions, we have been unable to identify them. The three are:

Ventrarma callosa Navas, 1924, Broteria, Serie Zoologica, 21: 78. Costa Rica.
Ventrarma spinosa Navas, 1930, Rev. Soc. Ent. Argent., 3: 131. Argentina.
Atopsyche aculeatum (Blanchard). Ulmer, 1913, Deutsch. Ent. Zeit., 4: 383. Chile.

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AMERICAN SOCIAL INSECTS, by CHARLES D. AND MARY H. MICHENER. xiv+267 pp., 109 figures. D. Van Nostrand Co. Price, $6.00.

This is the second volume of the New Illustrated Naturalist series to deal with an entomological subject (*cf.* Ann. Ent. Soc. Amer., 43: 45, 1950). The versatile authors have handled their intriguing subject very well and have developed its possibilities in such a way as to produce an interesting book that is not too elementary for the professional entomologist but which can at the same time be enjoyed by the average nature lover. The style is clear and free from unnecessary technicalities. The illustrations, many of them in color, are exceptionally good, from the standpoint of clarity, composition, subject matter, artistry and all-round excellence.

The book is divided into six parts. The first discusses the nature of social life among insects, its development, and its classification. The following four parts deal respectively with the four major groups of social insects: the social wasps, the social bees, the ants, and the termites. The final part deals with two subjects, namely, the social parasites of insect societies, and a comparison of insect and human societies. An appendix is added for the benefit of the reader who is unfamiliar with insect structure and classification.—M. T. J.

THE GENUS CYBAEUS (ARACHNIDA: AGELENIDAE) IN OREGON[1]

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A study on the North American spiders of the genus *Cybaeus* was published by Dr. R. V. Chamberlin and Wilton Ivie in 1932 (Chamberlin & Ivie, 1932). In this paper five species of *Cybaeus* were recorded from Oregon. Since then, five additional species have been described from the state (Chamberlin & Ivie, 1942). Since synonomy of the above species is in these papers, the reference given for each species discussed in this paper indicates only the best description or illustration. In this paper *Cybaeus cascadius* and *C. simplex* are described as new. The allotype (female) for *C. scopulatus* Chamberlin & Ivie is described and the male genitalia of *C. multnoma* Chamberlin and Ivie is illustrated for the first time. Specimens from Oregon representing four new species are being retained till additional and better specimens are obtained. Unless otherwise indicated all specimens were collected by the author.

The author wishes to thank Dr. C. H. Martin of Oregon State College, under whose guidance this study was made, for much valuable advice and assistance. The author is also indebted to Mr. F. Beer of Oregon State College who accompanied him on many collecting trips. To Drs. R. V. Chamberlin of the University of Utah and W. J. Gertsch of the American Museum of Natural History and Mrs. D. L. Frizzell (Harriet Exline) of Rolla, Mo., all of whom generously compared specimens and loaned named specimens, the author wishes to express his sincerest thanks.

During the study of the Oregon species of *Cybaeus* two misconceptions concerning the external morphology were noted. The median tarsal claw bears two, three, and occasionally four teeth. Chamberlin and Ivie (1932:5) in their review of the genus state only one tooth is present. In addition, the posterior spinnerets were found to be at least secondarily segmented, rather than consisting of a single segment as reported by authors. A study of the posterior spinnerets of the related genera *Cybaeina* and *Cybaeota* also indicated secondary segmentation.

DEFINITIONS

The following terms are defined to clarify their usage in this paper.

Measurement of the Head: The width of the head opposite the posterior margin of the posterior eyes.

[1]This is part of the material submitted to the Graduate School of Oregon State College in partial fulfillment of the requirements for the degree of Master of Science.

Published with the approval of the Monographs Publication Committee, Oregon State College, Research Paper No. 193, School of Science, Department of Entomology.

Median sclerite: A glabrous plate arising between the fertilization ducts at the epigastric furrow and extending medially to either the openings of the connecting canals or to the sclerotized sheet. It is usually lighter colored than the sclerotized sheet and is often heavily sclerotized along the lateral edges.

Sclerotized sheet: The thinly sclerotized sheet, sparsely covered with setae, which partially or wholly cover the internal genitalia. It is bounded laterally by the book lungs and posteriorly by the epigastric furrow. The anterior boundary lies at the point where the sheet begins to darken or just anterior of the limits of the internal epigynum. Usually the sheet is well defined in more mature specimens but it is almost indistinguishable from the remaining integument in teneral specimens.

Tertiary spermatheca: The first bulbous cavity between the opening of the connecting canal and the secondary spermatheca.

DISTRIBUTION AND HABITS

The majority of the species of *Cybaeus* are found in Northwestern United States and Northern California. Of the 36 species known in the United States, 13 have been collected in Oregon including the two new species described herein. The genus is represented in Oregon by hydrophilous, apparently nocturnal, spiders, which are usually found under rotting logs, bark, moss, duff, and in dry stream beds under rock. The author has never seen these spiders in webs. In most instances the spiders were found in, or adjacent to, Douglas fir, true fir, cedar, or hemlock forests. Occasionally they were found in deciduous forests which apparently formerly contained coniferous forests.

KEY TO THE OREGON SPECIES OF THE GENUS CYBAEUS

1. AME small, less than two-thirds the size of an ALE; patellar process of male projecting laterally (except in *C. scopulatus* Chamberlin and Ivie which bears a scopula beneath tibia I); female epigynum with two excavations or, if one, either very small and more or less quadrate or very large and longer than wide 2
   AME large, at least seven-eights the size of ALE; patellar process of male projecting forward; female epigynum with a single, large median excavation, wider than long (fig. 16) ..... **signifer**
2. Females 11
   Males. (No males known for *conservans, janus,* nor *constrictus*) 3
3. Dense scopula absent on tibia I 4
   Dense scopula ventrally on tibia I (fig. 24) ..... **scopulatus**
4. Patellar process stout, not thumb-like; much shorter than width of patella 6
   Patellar process thumb-like; as long as width of patella 5
5. Patellar process extending ectally at right angles to patella ..... **septatus**
   Patellar process extending anterio-ectally at a 40°–50° angle to the patella, (figs. 9, 12) ..... **simplex**
6. Cariniform process extending almost the entire length of the tibia of the palpus 7
   Cariniform process extending one-third or less the length of the tibia of the palpus (fig. 30) ..... **exlinae**
7. Palpal organ much wider than cymbium; conductor very large, as wide or wider than the patella and process combined (fig. 18) ..... **reticulatus**
   Palpal organ as wide as cymbium or slightly smaller; conductor normal, much more narrower than the patella and process combined 8
8. Caudal process of conductor straight and acuminate 9
   Caudal process of conductor not straight and acuminate 10

9. Caudal process of conductor pointing ectally (figs. 15, 33)..... **eutypus**
Caudal process of conductor pointing posterio-ectally (figs. 5, 6, and 7), ... **cascadius**
10. Caudal process of conductor more or less rounded distally (fig. 31)... **morosus**
Caudal process of conductor short, curved, and spur-like distally (fig. 3), ... **multnoma**
11. External epigynum with a single median excavation along the posterior border or with a single arched fold anterior of the excavations..... 12
External epigynum with two excavations or without a single arched fold anterior of the excavations..... 16
12. Median excavation small, sub-quadrate..... 13
Median excavation large, extending almost the length of the sclerotized sheet..... 15
13. Connecting canals visible as two or four transverse bars, the anterior canals often "L" or "U" shaped (fig. 22)..... **reticulatus**
Transverse connecting canals not visible..... 14
14. Two spermathecae visible as darkened areas[2] (figs. 25, 26)..... **exlinae**
Three spermathecae visible as darkened areas[2] (figs. 13, 14)..... **scopulatus**
15. Connecting canal openings under anterior arched fold (figs. 10, 11)... **simplex**
Connecting canal openings posterior to anterior arched fold (fig. 29)... **septatus**
16. Excavations large, each at least one-third the width of the sclerotized sheet and transversely elongate..... 17
Excavations small, each less than one-fifth the width of the sclerotized sheet and circular in shape or more or less covered by the sclerotized sheet..... 19
17. Excavations about one-half as wide as long; sclerotized sheet forming an edge over the anterior portion of the excavation..... 18
Excavations about two-thirds as wide as long; sclerotized sheet narrow anteriorly and not extending over excavation (fig. 8)..... **cascadius**
18. Median sclerite constricted slightly between excavations (fig. 17)..... **eutypus**
Median sclerite not constricted between excavations (fig. 23)..... **janus**
19. Connecting canal openings circular and facing ventrally or opening into a circular atria..... 20
Connecting canal openings not circular, facing posteriorally (figs. 2, 20), ... **multnoma**
20. Connecting canal openings located in a circular atria (fig. 19)..... **morosus**
Connecting canal openings arise on surface of sclerotized plate..... 21
21. Connecting canal openings widely separated, at least three times the diameter of the opening (fig. 28)..... **conservans**
Connecting canal openings close together, separated by slightly more than the diameter of the opening..... **constrictus**

Cybaeus signifer Simon

Figs. 16, 32

Chamberlin and Ivie, 1932, Bull. Univ. Utah 23: 12–14, figs. 24–5 (♂), 32 (♀).

This widespread species is quite uncommon in Oregon, only three males having been taken during two years of collecting.

Distribution.—Corvallis. Also has been reported from Forest Grove and Grants Pass (Chamberlin & Ivie 1932:13). This species is known from Tulare Co., California to Vancouver Island, B. C. One specimen was recorded from "Alaska" (Emerton, 1920, p. 326).

Cybaeus reticulatus Simon

Figs. 18, 22

Chamberlin and Ivie, 1932, Bull. Univ. Utah, 23: 17–18, figs. 40–1 (♂), 42 (♀).
C. reticulatus tius Chamberlin and Ivie, 1932, Bull. Univ. Utah, 23:19. New synonymy.

[2]Do not mistake the darkened areas at the openings of the connecting canals for spermathecae.

In the course of study of the genus *Cybaeus* 162 specimens of *C. reticulatus* Simon from Oregon, Washington, and Alaska[3] have been brought together from various collections. The author is especially grateful to Dr. M. H. Hatch of the University of Washington, to E. A. Chapin of the U. S. National Museum, and to Mrs. Don L. Frizzell (Harriet Exline) of Rolla, Mo. for loans of specimens. A study of these specimens indicated a wide range in size as is true for many agelenids but there is no clear indication of two separate groups. The palpal organ of the male was found to be expanded or contracted as often in the larger specimens as in the smaller specimens. Because of the lack of differentiation between the small and large spiders the author regards the variety *C. reticulatus tius* Chamberlin and Ivie as a synonym of *C. reticulatus* Simon.

Distribution.—This species is found commonly in Oregon on the west slope of the Cascade Mountains to the coast and south of the Columbia River to Lane County. One specimen was seen from Baker, Oregon, collected by M. H. Hatch. It has been recorded from "California" (Chamberlin & Ivie, 1932, p. 18). Many specimens were seen from Washington, the southern coast of Alaska and Unalaska in the Aleutian Islands.

Cybaeus conservans Chamberlin & Ivie

Fig. 28

Chamberlin and Ivie, 1932, Bull. Univ. Utah, 23: 21, fig. 51 (♀) (not 50).

Distribution.—Ashland and Roseburg (Chamberlin & Ivie 1932:21). No specimens of this species were taken by the author. The male is apparently unknown.

Cybaeus multnoma Chamberlin & Ivie

Figs. 1–3, 20

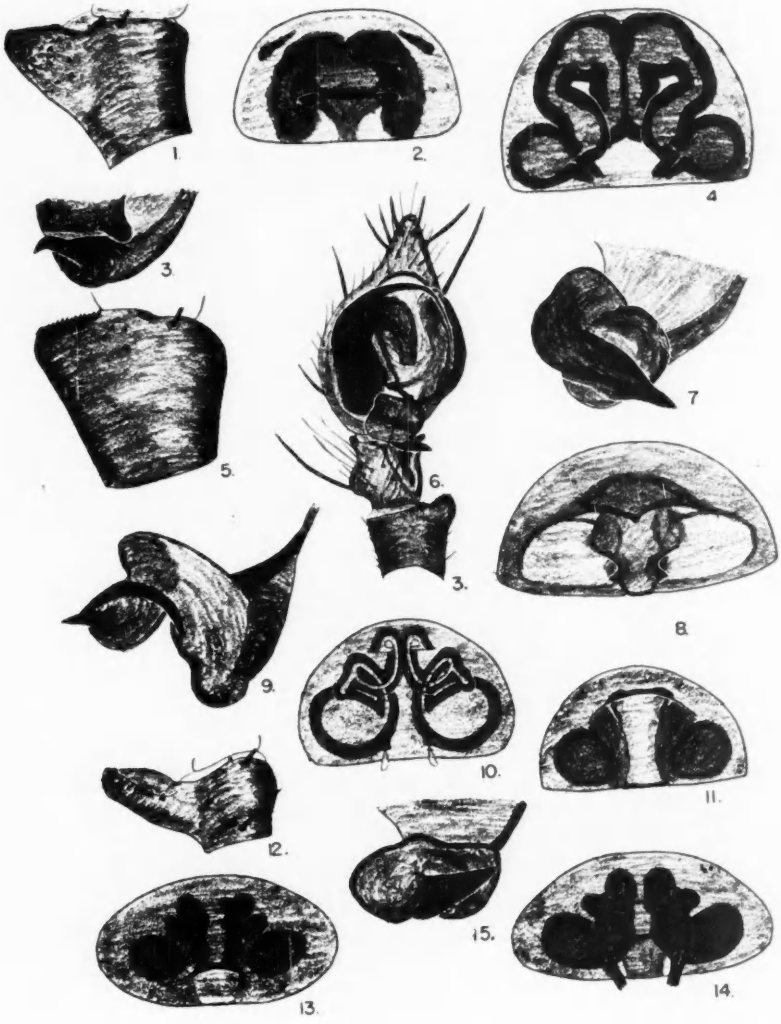
Chamberlin and Ivie, 1942, Bull. Univ. Utah, 32: 14–15, fig. 43(♀).

In the original description Chamberlin and Ivie designated a male paratype but no description or illustration was given of that sex. A description of the male genitalia is hereby given with illustrations.

[3]Mr. Levi of Wausau, Wis., stated (verbally) that Longmire, the type locality of the variety is in Washington instead of Wisconsin.

EXPLANATION OF PLATE I

FIG. 1. *Cybaeus multnoma* Chamberlin and Ivie, dorsal aspect of the patella of the male left palpus. FIG. 2. Same, ventral aspect of the female epigynum. FIG. 3. Same, caudal process of the conductor of a male left palpus, ventral aspect. FIG. 4. *C. cascadius* n. sp., dorsal aspect of the dissected female epigynum. FIG. 5. Same, dorsal aspect of the patella of the male left palpus. FIG. 6. Same, left palpus of the male. FIG. 7. Same, caudal process of the conductor of the male left palpus. FIG. 8. Same, ventral aspect of the female epigynum. FIG. 9. *C. simplex* n. sp., caudal process of the conductor of the male left palpus, ventral aspect. FIG. 10. Same, dorsal aspect of the dissected female epigynum. FIG. 11. Same, ventral aspect of the female epigynum. FIG. 12. Same, dorsal aspect of the patella of the male left palpus. FIG. 13. *C. scopulatus* Chamberlin and Ivie, ventral aspect of the female epigynum. FIG. 14. Same, dorsal aspect of the dissected female epigynum. FIG. 15. *C. eutypus* Chamberlin and Ivie, caudal process of the conductor of the male left palpus, ventral aspect.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Palpus of male moderately large, similar in general structure to that of *C. cascadius* n. sp. (fig. 6). Apical portion of cymbium short and stout. Patella slightly shorter than tibia and with a prominent process ecto-distally about two-thirds as long as the width of the patella, the process extending distally at about a 40° angle, and bearing, dorsally, 30 to 40 small, black, conical teeth scattered over the entire surface but concentrated more or less distally. Tibia with a hump dorsally and produced meso-distally into a short, dull point. A stout cariniform process extending the length of the tibia and borne ecto-ventrally. Caudal process of conductor moderately large and terminating in a slightly curved point as illustrated in fig. 3.

The female epigynum was found to be quite variable but generally resembled figure 2.

Distribution.—OREGON: Roseburg, (type locality), Charleston, July, 1950 (♀); 10 Mi. S. Coquille, May 30, 1948 (♀); 12 Mi. E. Cave Junction, matured in laboratory Aug. 9, 1948 (♂); Blue Pool Forest Camp, Williamette National Forest, Sept. 7, 1949 (4♀); Cascadia (within 10 miles) July 23, 1949, Mar. 7, 1948, May 30, 1949 and Sept. 5, 1948, F. Beer & V. Roth collectors (16♀–9♂). CALIFORNIA: 9 Miles north of Crescent City, May 30, 1948, E. E. Brown and V. Roth (♀); Crescent City, Aug. 11, 1950 (♀).

Cybaeus constrictus Chamberlin & Ivie

Chamberlin and Ivie, 1942, Bull. Univ. Utah, 32: 15, fig. 49 (♀).

Known only from the type locality at Tillamook Co., Oregon.

Cybaeus morosus Simon

Figs. 19, 31

Chamberlin and Ivie, 1932, Bull. Univ. Utah, 23: 20–21, figs. 3–4, 46–47 (♂), 1–2, 48–49 (♀).

Distribution.—*C. morosus* Simon is distributed in Oregon mostly along the Coast Range south to Charleston and in the Willamette

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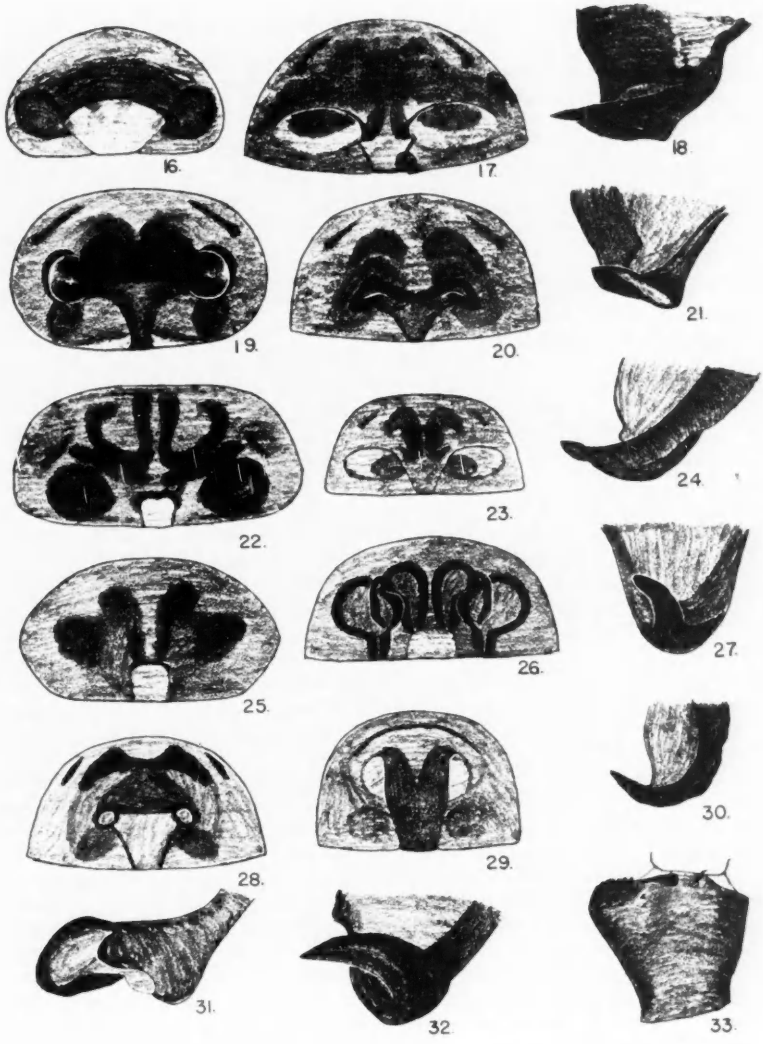
EXPLANATION OF PLATE II

FIG. 16. *Cybaeus signifer* Simon, ventral aspect of the female epigynum. FIG. 17. *C. eutypus* Chamberlin and Ivie, same. FIG. 18. *C. reticulatus* Simon, caudal process of the conductor of a male left palpus. FIG. 19. *C. morosus* Simon, ventral aspect of the female epigynum. FIG. 20. *C. multnoma* Chamberlin and Ivie, ventral aspect of the female epigynum of the holotype. FIG. 21. *C. scopulatus* Chamberlin and Ivie, caudal process of the conductor of the male left palpus, ventral aspect. FIG. 22. *C. reticulatus* Simon, ventral aspect of the female epigynum. FIG. 23. *C. janus* Chamberlin and Ivie, ventral aspect of the female epigynum of a paratype. FIG. 24. *C. scopulatus* Chamberlin and Ivie, caudal process of the conductor of a male left palpus, ectal aspect. FIG. 25. *C. exlinae* Chamberlin and Ivie, ventral aspect of the female epigynum. FIG. 26. Same, dorsal aspect of the dissected female epigynum. FIG. 27. Same, caudal process of the conductor of a male left palpus, ventral aspect. FIG. 28. *C. conservans* Chamberlin and Ivie, ventral aspect of the female epigynum of a paratype. FIG. 29. *C. septatus* Chamberlin and Ivie, same. FIG. 30. *C. exlinae* Chamberlin and Ivie, caudal process of the conductor of a male left palpus, ectal aspect. FIG. 31. *C. morosus* Simon, caudal process of the conductor of a male left palpus, ventral aspect. FIG. 32. *C. signifer* Simon, caudal process of the conductor of a male left palpus, ventral aspect. FIG. 33. *C. eutypus* Chamberlin and Ivie, dorsal aspect of the patella of the male left palpus.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Valley south to Roseburg (Chamberlin & Ivie, 1932:21). This species is also known along the coast northward to Unalaska in the Aleutian Islands of Alaska.

Cybaeus eutypus Chamberlin & Ivie

Figs. 15, 17, 33

Chamberlin and Ivie, 1932, Bull. Univ. Utah, 23: 19–20, figs. 43–44 (♂), 45 (♀).

Distribution.—*C. eutypus* Chamberlin & Ivie has been collected in Oregon as far south as Roseburg, north to the Columbia River, and from the west slope of the Cascade Range to the coast. This species has also been recorded from Western Washington and one specimen was taken near Victoria, Vancouver Is., British Columbia.

Cybaeus janus Chamberlin & Ivie

Fig. 23

Chamberlin and Ivie, 1942, Bull. Univ. Utah, 32: 15–16, fig. 44 (♀).

Known only from the type locality at Comstock, Ore. Males apparently unknown.

Cybaeus cascadius n. sp.

Figs. 4–8

Holotype Male.—Color: Carapace reddish-brown, becoming darker anteriorly. Radial streaks emanating from the thoracic furrow and widening distally. Eyes ringed in black. AME connected with a black band as are the ALE and PLE. PME ringed with black. Chelicerae dark reddish brown, endites and labium yellowish brown, white distally. Sternum slightly darker yellowish brown than endites, becoming darker at the edges. Legs yellowish to reddish brown with very faint annulations, two on femur, one on the patella and two on the tibia. Abdomen dark gray above with light gray markings in the form of a medium linear mark on the anterior part of the abdomen and with two large spots on either side and three chevrons posterior of the linear mark. Abdomen mottled gray laterally. Venter light gray.

Structure: Typical of the genus. Carapace longer than broad, the widest point opposite the forward edge of the thoracic furrow. Carapace slanting steeply from the posterior edge of the thoracic furrow to the posterior margin of the carapace. Sides of head slightly convergent anteriorly. Anterior eye row slightly recurved, posterior eye row recurved slightly more than anterior row. Eye ratio: AME:9 PME:13, PLE:14, ALE:15. AME separated by one and one-third times their own diameters and one radius from the ALE. AME about one-half their diameter from the ALE. PME slightly more than their diameter apart. Clypeus approximately one and one-third diameters of an ALE. Chelicera strongly geniculate, four teeth and five denticles on the retromargin of the holotype. Usually five teeth and five denticles. Fang with usual row of overlapping hairs. Labium wide as long and slightly more than one-half the length of the endites. Endites parallel, about two-thirds as wide as long. Dense scopula on mesal half of anterior margin and serrula present on ectal half. Sternum as wide as long and shield shaped. Lateral edges of sternum opposite coxa III flattened and concave opposite coxa IV. Short acute process extending

between hind coxae. Abdomen subovate and slightly longer than wide. Spinnerets closely grouped. Anterior spinnerets contiguous, two segmented, the basal segment conical and the very short distal segment hemispherical. Median spinnerets contiguous. Posterior spinnerets slightly wider apart than the anterior spinnerets, two-segmented, the distal segment minute. Both segments shorter than the basal segment of the anterior spinnerets. Colulus divided, each half represented by three hairs. Opening of the spiracle slightly anterior to the colulus.

Palpus typical of the genus, moderately stout. Apical portion of cymbium short. Patella slightly shorter than tibia, produced slightly ecto-distally and bearing 30 to 35 small, black, conical teeth distally on the process. Tibia with a hump dorsally and produced meso-distally to a short dull point. A stout cariniform process extending the length of the tibia is borne ecto-ventrally. Caudal process of conductor stout, composed of a more or less rectangular base with an acuminate process extending posterio-ectally across the face of the base.

Legs of moderate length. All tibiae with three pair of spines. All metatarsi with a 2–2–3 pattern of spines ventrally. Median tarsal claw with two or three teeth.

Measurements (in millimeters):

Total length, 9.0. Average, (10♂), 8.67. Range, 7.7–9.2.

Carapace		Metatarsus	
Length	4.60	I	2.79
Width	3.33	IV	3.26
Head width	1.70		
Eye width	1.12	Tarsus	
Femur		I	2.07
I	3.00	IV	1.87
IV	3.60		
Tibia-patella		Total	
I	4.10	I	13.90
IV	3.80	IV	14.57

Allotype Female.—Very similar to the male but differs in the following respects. Head proportionately wider in comparison with the width of the carapace, legs slightly shorter and gross size usually greater. Epigynum quite unusual: larger than normal with most of the external area membranous. Sclerotized sheet very narrow along the posterior, anterior, and lateral edges; corrugated transversely, thinly covered with setae, and bearing laterally a pair of strongly sclerotized depressions (lateral sclerites). Two large ovate excavations two-thirds as long as wide lying transversely and divided by a wide median sclerite. Median sclerite arrowhead-shaped and truncate posteriorly. The connecting canals opening mesally in the excavations and hidden by the median sclerite.

Dissection (from paratypes from the type locality): Epigynum internally consisting of two more or less identical right and left parts. Connecting canal extending from the opening, mesally to the median line and turning anteriorally to the globose tertiary spermatheca. A connecting canal extending from the ectal portion of the spermatheca posteriorly where it gradually enlarges to form an elongate secondary spermatheca which is swollen posteriorly and bears internally a minute, darkened circular disk at the posterio-mesal area. A short connecting

canal connecting the secondary spermatheca to the globose primary spermatheca. A slender fertilization duct arising at the junction of the connecting canal and the primary spermatheca and converging posteriorly.

Measurements (in millimeters:)

Total length, 9.7. Average, (17 ♀), 8.98. Range, 7.4–11.5.

Carapace		Metatarsus	
Length	4.70	I	2.60
Width	3.25	IV	3.20
Head width	2.18		
Eye width	1.29	Tarsus	
Femur		I	1.70
I	3.30	IV	1.75
IV	3.10		
Tibia-Patella		Total	
I	3.90	I	13.30
IV	3.90	IV	14.05

Type locality.—One mile west of Cascadia, Oregon, July 23, 1949; Frank Beer and V. Roth collectors.

Paratypes.—Thirty-two females and 10 males collected from an area between one mile west of Cascadia and Tombstone Prairie, about 18 miles to the east on the Santiam Highway: One mile west of Cascadia, Dec. 31, 1950 (♀), April 18, 1948 (♀), Sept. 5, 1948, (10 ♀), Sept. 11, 1948 (♀), July 23, 1949, F. Beer & V. Roth collectors (5 ♂ 2 ♀); Tombstone Prairie, Sept. 11, 1948 (♀), Aug. 13, 1949 (2 ♂, 12 ♀), May 27, 1949, F. Beer & V. Roth collectors (♀); 27 miles N. E. Sweet Home, Mar. 7, 1948 (♀); House Rock Forest Camp, 13 miles east of Cascadia, July 23, 1949, V. Roth & F. Beer collectors (♂, 2 ♀); Lambs Creek, 17 miles east of Cascadia, July 23, 1949, V. Roth & F. Beer collectors (2 ♂).

The holotype and allotype will be deposited in the collection of Dr. R. V. Chamberlin at the University of Utah. A male and female paratype will be deposited in the American Museum of Natural History, New York, the Museum of Comparative Zoology at Cambridge, Massachusetts, the U. S. National Museum at Washington, D. C., the California Academy of Science, and the collection of Mrs. D. L. Frizzell (Harriet Frizzell) at Rolla, Missouri. The remainder of the paratypes will be retained in the author's collection.

The name *cascadius* was designated because this species has been found only in the Cascadia area up to this writing.

This species is close to *C. eutypus* Chamberlin & Ivie but differs distinctly as follows. *C. cascadius:* Caudal process of conductor with an acuminate process extending posterio-ectally across its base. Sclerotized sheet atrophied, membranous tissue covering the internal organs. *C. eutypus:* Caudal process of conductor with an acuminate process extending ectally across its base. Sclerotized sheet not atrophied, entirely covering the internal genitalia which are identical to *C. cascadius*.

Cybaeus scopulatus Chamberlin & Ivie

Figs. 13, 14, 21, 24

Chamberlin and Ivie, 1942, Bull. Univ. Utah, 32: 13–14, figs. 39–40 (♂).

Allotype Female.—Color: Carapace yellowish brown, with dusky

markings. Sides of head with stronger dusky markings than found on the thorax. Three pair of radial streaks emanating from the thoracic furrow. Eyes ringed in black. AME connected with a black band as are the PLE and ALE. Chelicerae reddish brown. Abdomen dark gray with whitish gray markings in the form of a light gray, median, linear mark on the anterior part of the abdomen and with two large gray spots on either side and three chevrons posterior of the linear mark. Abdomen mottled gray laterally. Venter light gray. Legs yellowish with very faint annulations, only two being visible ventrally on the femora.

Structure: Typical for the genus. Carapace longer than broad, the widest point opposite the forward edge of the thoracic furrow. Carapace slanting steeply from the posterior edge of the thoracic furrow to the posterior edge of the carapace. Sides of the head parallel. Anterior eye row slightly recurved, posterior row slightly more recurved. Eye ratio: AME:7.5, PME:9.3, PLE:10, ALE:12. AME slightly more than their diameter apart and about ⅔ of their diameter from the ALE. Lateral eyes separated by half their diameter. PME slightly less than one and one-half diameters apart. Clypeus approximately one and one-third the diameter of an ALE. Chelicerae strongly geniculate, with three teeth and four denticles on the retromargin of the right chelicera and four teeth and three denticles on the retromargin of the left chelicera of the allotype. Fang with usual row of overlapping hairs. Labium slightly wider than long and about half as long as the endites. Endites slightly convergent distally. Dense scopula on mesal half of anterior margin and serrula present on ectal half. Sternum longer than wide and shield shaped. Lateral margins angulate opposite coxae II, III, IV. Short acute process extending half-way between the basal portions of the hind coxae. Abdomen sub-ovate and slightly longer than wide. Anterior spinnerets contiguous, two segmented. Posterior spinnerets widely separated, two segmented, together smaller than the basal segment of the anterior spinnerets. Colulus divided, each half represented by a few hairs. Opening of the spiracle slightly anterior to the colulus.

Epigynum externally consisting of a thin sclerotized sheet with a small median opening on the posterior half. Junction of the open ends of the two connecting canals forming the median opening. Connecting canals joined mesally at their open ends and the anterior and ventral edges of the openings thickened continuously, forming a thickened transverse lip, over the two openings. From each lateral edge of the transverse lip, a sclerotized line separating the trapizoidal median sclerite which is widest anteriorally and extends to the epigastric furrow.

Dissections (from specimens from Suttle Lake, Ore.): Epigynum internally composed of more or less identical right and left halves, only one-half of which is considered in the following description. Connecting canal extending anteriorly from the opening a very short distance and opening into a club-like tertiary spermatheca. A connecting canal arising ventrally in the middle of the spermatheca, enlarging to form the secondary spermatheca and forming a "C" curve over the basal half of the tertiary spermatheca. At the posterior mesal area of the secondary spermatheca, an indentation in the wall with a few ducts

or cells penetrating the wall. A short connecting canal extending from the secondary to the primary spermatheca. Primary spermatheca subovate, tapered more or less mesally and lying at about a seventy degree angle to the median line. Fertilization ducts moderately convergent posteriorly.

Legs of moderate length. Tibiae I, II, and III with three pair of spines ventrally, IV with 1–2–2 spines. All metatarsi with a 2–2–3 pattern of spines ventrally. (Right metatarsus with a 2–2–2 pattern of spines, the center spine not present in the allotype.) Median tarsal claw with three teeth. (Other specimens have two or three and occasionally four teeth.

Measurements (in millimeters):

Total length, 6.8. Average length, (10 ♀), 6.26. Range, 5.9–6.8.

Carapace		Metatarsus	
Length	3.10	I	1.70
Width	2.18	IV	2.55
Head width	1.33		
Eye width	.85	Tarsus	
Femur		I	1.09
I	2.55	IV	1.36
IV	2.65		
Tibia-patella		Total	
I	2.72	I	9.38
IV	2.99	IV	10.95

Allotype locality.—Collected 10 miles S. of Parkdale, Oregon, Sept. 16, 1949 by the author.

Eleven other females and two males were taken with the allotype. Other new records include: OREGON: Suttle Lake, Santiam Pass, May 27, 1949, F. Beer & V. Roth, collectors (3 ♀); 5 miles west of Hogg Pass at Lost Lake, Sept. 11, 1948 (♀); Tombstone Prairie, Santiam Pass, Aug. 13, 1949 (♀), July 12, 1949, V. Roth & F. Beer, collectors (♂).

The original description of *C. scopulatus* Chamberlin & Ivie was based on a single male from Perham Creek, Columbia River Gorge, Ore. The male has tibia I semi-scopulate ventrally, the only species in this genus with such an ornamentation. This scopula is lacking in the penultimate instar of the male and in the female.

The allotype will be deposited in the collection of Dr. R. V. Chamberlin at the University of Utah.

Cybaeus exlinae Chamberlin & Ivie

Figs. 25–27, 30

Chamberlin and Ivie, 1937, Ann. Ent. Soc. Amer., 30: 224–225, figs. 62–63 (♂), 64 (♀).

Distribution.—Tamarack, Idaho (type locality), Langdon Lake, Ore., near Toll Gate in the Blue Mountains, Sept. 13, 1949 (♂–4 ♀); Langdon Lake, Ore., Sept. 19, 1937, M. Hatch, collector (♀), (from the collection of Mrs. D. L. Frizzell).

Cybaeus simplex n. sp.

Figs. 9–12

Holotype Male.—Color: Carapace light yellowish-orange, becoming darker anteriorly, lacking dusky markings. Eyes ringed with black,

AME with a connecting black band as are the ALE and PLE. Chelicerae brownish orange, endites and labium slightly lighter, white on tips. Sternum yellow, becoming yellowish-orange at the edges. Legs yellowish, lacking dusky markings. Abdomen light gray with dusky markings dorsally outlining a median lanceolate mark over the heart and four pair of indistinct chevrons on the posterior half.

Structure: Typical of the genus. Carapace longer than broad, widest opposite the anterior end of the furrow. Carapace evenly convex, sloping forward at the eyes. Sides of head slightly convergent anteriorly. Posterior eye row moderately recurved. Anterior row slightly recurved. Eye ratio AME:6, PME:7.5, ALE and PLE:10. AME a diameter apart and one radius from the ALE. Lateral eyes less than half a radius apart. PME slightly less than one and one-half diameters apart. Clypeus slightly wider than the diameter of the ALE. Chelicera moderately geniculate, three teeth on the promargin and four teeth, four denticles on the retromargin. Fang with usual row of overlapping hairs. Labium slightly wider than long, about half as long as the endites. Endites converge slightly distally. Dense scopula on mesal half of anterior margin and serrula present on ectal half. Sternum slightly longer than wide, shield shaped, slightly angulate opposite coxae II, III, and IV. Short process extending between hind coxae. Abdomen subovate, slightly longer than wide. Spinnerets closely grouped, not visible from a dorsal view. Anterior spinnerets contiguous, two-segmented, the basal segment conical and the very short distal segment hemispherical. Posterior spinnerets two-segmented, together shorter than basal segment of anterior spinnerets. Colulus divided, each half represented by four hairs. Opening of spiracles slightly anterior to the colulus.

Palpus of male typical for genus. Patellar process prominent, thumb-like, and extending outward at a forty-five degree angle. Process bears 20 to 25 minute, conical, black teeth distally on dorsal side. Tibia bears a stout cariniform process ecto-ventrally. Caudal process of conductor convoluted distally as illustrated in fig. 7.

Legs of moderate length. All tibiae with three pair of spines ventrally. Metatarsi with 2–2–3 spines ventrally. (Only 2 instead of 3 spines distally on right tibia I on holotype). Median tarsal claw with 3 or 4 teeth.

Measurements (in millimeters):

Total length, 5.1. Average, (6 ♂), 4.55. Range, 3.9–5.1.

Carapace		Metatarsus	
Length	2.55	I	1.70
Width	1.87	IV	2.31
Head width	1.05		
Eye width	.59	Tarsus	
Femur		I	1.02
I	2.07	IV	1.29
IV	2.18		
Tibia-patella		Total	
I	2.86	I	7.65
IV	2.41	IV	8.19

Allotype Female.—Similar to the male but differing in having the general coloration lighter, chelicerae strongly geniculate and the head

proportionately wider. Epigynum consisting of a smooth sclerotized sheet lacking sclerotized depressions. An anterior transverse fold extending over the paired connecting canal openings. Posterior to the openings, the median sclerite extending posteriorly to the epigastric furrow. The sclerite slightly raised in the center for its entire length, arising at the lateral edges of the openings of the connecting canals, rapidly narrowing to about three-fifth the original width, and extending posteriorly to the posterior edge of the sclerotized sheet where it widens slightly. The sclerite about four times as long as its wide in the center. The spermathecae are the only internal structures visible through the sclerotized sheet.

Dissection from paratypes from the type locality: Epigynum internally simplified greatly but consisting of two separate halves (one side considered in the description). Connecting canal arising on the anterior half of the sclerotized sheet and extending anteriorly a very short distance, curving dorsally and posteriorly past the opening of the canal and then curving laterally where a short blind duct, apparently a degenerate tertiary spermatheca, arises. Connecting canal continuing mesally and posteriorly where it connects with the spermatheca with no changes in the size of the canal. Just prior to the primary spermatheca on the mesal area of the connecting canal, a small indentation in the wall of the canal, arising where the secondary spermatheca should be and similar to the odd structures found in many of the secondary spermatheca in *Cybaeus*. Primarily spermatheca ellipsoidal and almost transverse. Fertilization duct arising at the posterio-mesal edge of the spermatheca and extending posterio-mesally.

Measurements (in millimeters):

Total length, 4.6 mm. Average, (7 ♀), 4.6. Range, 4.0–5.1.

Carapace		Metatarsus	
Length	2.21	I	1.36
Width	1.60	IV	1.70
Head width	1.16		
Eye width	.56	Tarsus	
Femur		I	.95
I	1.70	IV	1.09
IV	1.77		
Tibia-Patella		Total	
I	2.07	I	6.09
IV	2.18	IV	6.73

Type locality.—The holotype and allotype were collected by the author one mile west of Cascadia, Oregon, under bark, about one inch apart. Sept. 11, 1948.

Paratypes.—Two ♀ and 3 ♂ from the type locality, Sept. 11, and 2♂, 2♀ Sept. 5; 1♀ from one mile E. of Quartzville, Ore. under log, Mar. 7, 1948; 1♀ from Blue Pool Camp, Willamette National Forest, Sept. 7, 1949. All paratypes collected by the author.

The holotype and allotype will be deposited in the collection of Dr. R. V. Chamberlin at the University of Utah. A male and female paratype will be deposited in the American Museum of Natural History, New York, Museum of Comparative Zoology at Cambridge, Mass. and the U. S. National Museum at Washington D. C. The remaind

of the paratypes will be retained in the author's collection for the present.

The simple structure of the internal genitalia of the female suggested the name *simplex* for this species.

C. simplex is similar to *C. septatus* Chamberlin and Ivie but differs as follows:

C. simplex: Patellar process of the male extends outward at a 45° angle. (Caudal process of the conductor is distinct for each species but no male *C. septatus* Chamberlin & Ivie was on hand for comparison.) Transverse ridge of the epigynum overlaps connecting canal openings. Median sclerite constricted in the middle.

C. septatus: Patellar process of the male extends outward at right angles. Transverse ridge of the epigynum separated from the connecting canal openings. Median sclerite not constricted in the middle.

Cybaeus septatus Chamberlin & Ivie

Fig. 29

Chamberlin and Ivie, 1942, Bull. Univ. Utah, 32: 17, figs. 41 (♂), 42 (♀).

Recorded from Grants Pass, Oregon, and Weed and Potter Creek Cave, California (Chamberlin & Ivie, 1942:17). Not collected by the author.

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TAXONOMY OF VASCULAR PLANTS, by GEORGE H. M. LAWRENCE. xiii+823 pages, 322 figures. The Macmillan Co. 1951. Price, $7.95.

Whether because of the close association of insects with plants or because of an interest in taxonomy, most entomologists will find much of interest in this admirable volume. The first part, 331 pages, deals with the principles and practices of plant taxonomy, a more extensive treatment than will be found in any book dealing with the zoological side of the subject, at least in English. An up-to-date and detailed treatment of the International Rules of Botanical Nomenclature is included. The history of plant taxonomy is treated in sufficient detail to provide the basis for an illuminating comparison with the development of zoological taxonomy.

We learn that a fourth edition of the botanical rules is forthcoming, which will include a number of changes adopted in 1950. The botanical code, in comparison with that of zoological nomenclature, is live and growing. The term *taxon* (plural *taxa*) was adopted to indicate taxonomic groups of any rank as being more adequate and specific than such ambiguous terms as entity or taxonomic group.—GEORGE C. STEYSKAL.

A STUDY OF THE PHYSIOLOGY OF RESISTANCE TO HYDROCYANIC ACID IN THE CALIFORNIA RED SCALE[1]

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INTRODUCTION

The resistance of the California red scale, *Aonidiella aurantii* (Mask.), to hydrocyanic acid is a matter of practical as well as theoretical interest. Certain strains have become highly resistant to this fumigant, whereas other strains show no such resistance. It is evident from genetic studies that resistance is inherited, but there are no discernible morphological characteristics in which the resistant and nonresistant strains differ. Physiological differences between the strains must be the basis of variations in resistance to hydrocyanic acid. It is the purpose of this work to elucidate the nature of these differences.

Originating with the classic work of Warburg (Warburg 1925 and 1949), and now almost universally held, is the concept that the inhibitory action of cyanide on respiration and oxygen consumption is brought about by the inactivation of metal-containing respiratory enzymes through combination between the cyanide and the metal. The most usual site of such action, according to Keilin (1933) and others, is the iron of the metalloporphyrin of the cytochrome oxidase. Inactivation of these enzymes prevents the combination of the oxygen normally handled by these enzymes with the hydrogen removed from the substrate, and thus all, or a considerable portion, of the oxygen consumption of the majority of aerobic organisms is inhibited by low concentrations of cyanide. There are, however, a number of plant and animal cells that are at least partially resistant to this action of cyanide (Oppenheimer and Stern 1939, pp. 260–261). It is probable that this cyanide-resistant respiration is associated with activity of metal-free respiratory enzymes such as the autoxidizable flavo-protein enzymes of the type first described by Warburg and Christian (1932); since these enzymes contain no heavy metals, their activity is not impaired by cyanide in moderate concentrations.

A priori there would seem to be at least three different mechanisms through which the resistant strains could be less susceptible to the action of hydrocyanic acid. First—the resistant strains might have a lower oxygen requirement, and a lower oxygen consumption under normal conditions, thus being less sensitive to hydrocyanic acid; Robbie, Boell, and Bodine (1938) have demonstrated in the developing grasshopper that periods of high oxygen consumption are periods of high sensitivity to cyanide, and periods of low oxygen consumption are periods

[1]Presented at the meeting of the Pacific Slope Branch of the American Association of Economic Entomologists at Seattle, Wash., June 19–21, 1951.

of low sensitivity to cyanide. Second—the resistant strain might depend to a lesser extent on heavy metal-containing oxidases and more on the metal-free respiratory enzymes, thus having a respiratory enzyme system which is less inhibited by cyanide than that of the nonresistant stock. Third—the resistant strain might be able to withstand anoxia better than the nonresistant, possibly because of a greater store of anaerobic hydrogen acceptors or a "store" of oxygen; Robbie (1948) has suggested this possibility as explaining the difference in susceptibility of *Echinarachnius*, *Arbacia*, and *Fundulus* eggs to cyanide. The first possibility can be checked by determining the normal rates of oxygen consumption; in the second possibility, the oxygen consumption of the resistant strains should not be depressed as markedly as that of the sensitive strains upon hydrocyanic acid fumigation; and if the third possibility holds, the resistant strains should be able to survive for a longer period in an anoxic environment.

With these possibilities and objectives in mind, the following studies were made: Oxygen-consumption measurements of resistant and sensitive strains under normal conditions and after exposure to several concentrations of hydrocyanic acid; measurement of resistance to anoxia by mortality counts following exposure to an atmosphere of almost pure nitrogen for varying periods; determination of mortality with hydrocyanic acid and hydrogen sulfide for the different strains; and determination of the influence of protective stupefaction on the oxygen consumption.

MATERIALS AND METHODS

The California red scales used in these studies were the nonresistant, resistant, and super-resistant stocks previously described by Yust *et al.* (1951). The super-resistant stock has a history of 50 to 55 repeated fumigations in the laboratory. The test scales were reared on green lemon fruits at a temperature of 25° C. and a relative humidity of about 65 percent. In the mortality counts, unless otherwise stated, 100 insects of the same stage were included from each fruit. Females in the second molt and males tested were on the same fruits and were the same age. When the scales remained on the hosts the mortality counts were made about 2 weeks after treatment.

Oxygen consumption measurements were made with a differential microrespirometer of the type described by Barth and Kirk (1942). The essential features of the apparatus include two identical chambers, tooled in a rectangular metal block, that are in connection with each other through a fine glass capillary carrying a movable index droplet of redistilled kerosene. The two chambers were cut in a brass block, and after machining was completed, the unit was chromium-plated to provide a more inert surface. During measurement of oxygen consumption the chambers and the interconnecting capillary formed a closed system. The exposure chamber was charged with the insects to be studied and a drop of 0.5 *N* sodium hydroxide for absorption of carbon dioxide, the two items being held in separate depressions in a Lucite plate; the control chamber was similarly charged except that it contained no insects. Consumption of oxygen in the exposure chamber reduced the pressure in this chamber, thus making the pressure lower

than that in the control chamber; equalization of pressure in the closed system could occur only by the displacement of the index droplet toward the chamber in which the oxygen was consumed, and the displacement of the index was in proportion to the amount of oxygen consumed. Appropriate calibration of the capillary made possible the calculation of the actual volume of oxygen consumed for any given displacement of the index. A 30-minute equilibration period was allowed to elapse after the respirometer was charged before any readings were taken.

The respiration tests were made with lots of 10 pupal males selected at random from a single fruit. Pupal males were used because they are not attached to the host fruits and thus removal to the respirometer involved a minimum of injury due to manipulation. Usually ten tests were made with each stock. Each lot of insects was selected from a different fruit. The insects were carefully removed from the host with a camel's hair brush and put in a Lucite cup, which was placed in the respirometer chamber. After the respirometer tests the insects were placed in culture slides and held in the rearing room for evidence of damage from handling and of mortality where the scales were exposed to hydrocyanic acid. Nearly all the males emerged as winged adults; a maximum of 4 out of 100 died before emerging in checks on the effect of handling.

Exposure of insects to oxygen-deficient atmosphere was accomplished by continuous flushing of nitrogen through treatment chambers. Each chamber had a capacity of about 3920 cc., was made of metal, and was gastight except for an inlet and outlet. The chambers readily held 12 lemon fruits and when closed were dark. This was desirable to minimize oxygen production through photosynthesis. The nitrogen from the chamber was released under water to prevent any possibility of back flow of air into chambers. As many as four chambers connected in series were operated simultaneously. The nitrogen was more than 99.5 percent pure. The particular advantage of this method is that the scales are not removed from the host. No scale mortality resulted from flushing compressed air through the equipment in a similar manner for 22 hours.

Pupal males were weighed on a microbalance to determine whether there was any difference in the weight of the three stocks. Twelve lots of 30 scales of each stock were weighed under constant light condition at a constant temperature of 25° C. The weights were determined immediately after removal of the insects from the host material in the rearing room. The respective average weights of 30 nonresistant, resistant, and super-resistant males were 0.530 ± .005, 0.521 ± .004 and 0.526 ± .005 mg.; differences are statistically insignificant. Since the three stocks differed very little in weight, the lots of males tested for oxygen consumption were not weighed.

EXPERIMENTS AND RESULTS

Oxygen-Consumption Studies: The rate of oxygen consumption of the three stocks was measured under normal conditions and after exposure to hydrocyanic acid for 10 minutes. Only the highest dosage used against each stock resulted in kill. A concentration of 0.05 mg. per liter killed 42 percent of the nonresistant stock, that of 0.1 mg. per

liter killed 14 percent of the resistant stock, and that of 4.0 mg. per liter killed 20 percent of the super-resistant stock. The oxygen-consumption rate was determined by making readings at about 10-minute intervals for a period of 1 hour or more. For the fumigated scales the rate was determined for the second and third hours after treatment.

The displacement of the index was plotted against time, a line was fitted to the points, and the displacement for the 2-hour period was read from the curve and multiplied by the calibration factor to give oxygen consumption in cubic millimeters. The results are given in table I.

TABLE I

RATE OF OXYGEN CONSUMPTION FOR NONRESISTANT, RESISTANT, AND SUPER-RESISTANT PUPAL MALE SCALES WITHOUT AND WITH HYDROCYANIC ACID FUMIGATION

CONCENTRATION OF HCN, mg./l.	SECOND HOUR		THIRD HOUR	
	Number of tests	Oxygen uptake, mm^3/hr./10 pupae	Number of tests	Oxygen uptake, mm^3/hr./10 pupae
		Nonresistant		
0.000	10	.331 ± .010	....	.....
.025	11	.190 ± .010	10	.219 ± .005
.05	9	.095 ± .015	9	.126 ± .012
		Resistant		
0.00	10	.327 ± .010	....	.....
.05	10	.272 ± .008	10	.298 ± .007
.1	11	.160 ± .012	11	.201 ± .016
		Super-Resistant		
0.00	10	.316 ± .002	....	.....
.05	5	.321 ± .022	5	.329 ± .015
.06	10	.322 ± .011	10	.330 ± .008
1.0	10	.272 ± .007	10	.294 ± .004
2.0	10	.233 ± .018	10	.264 ± .017
4.0	10	.158 ± .011	10	.206 ± .013

In the absence of hydrocyanic acid the three strains used oxygen at about the same rate and the rate of consumption was constant during the test period. Using the average weights for male scales, the respective normal rates of oxygen consumption for the nonresistant, resistant, and super-resistant stocks on a weight basis were 1.876, 1.883 and 1.800 $mm.^3$/mg./hr. Thus there is no quantitative difference in the oxygen consumption of these three strains under normal conditions that can be used to explain variations in hydrocyanic acid resistance.

After exposure of the three stocks to 0.05 mg./liter of hydrocyanic acid, the oxygen consumption of the nonresistant stock was depressed 71 percent, that of the resistant stock 17 percent, whereas the oxygen consumption of the super-resistant stock was not depressed. The oxygen uptake of the nonresistant, resistant, and super-resistant stocks after exposure to hydrocyanic acid concentrations of 0.025, .05, and

1.0 mg./liter, respectively, was substantially reduced but the kill in each case was negligible. The oxygen uptake of the nonresistant scales was much less than that of the resistant scales, although the concentration used against the latter was twice that used against the former. The oxygen uptake of the resistant and super-resistant scales was about the same, although the concentration used against the latter was 20 times greater than that used against the former. After exposure to hydrocyanic acid, oxygen consumption was directly correlated with resistance and it is likely that during fumigation it bears the same relation.

The oxygen uptake during the third hour after fumigation was higher than during the second hour, an indication that the insects were recovering from the depressing effects of the hydrocyanic acid. The increase occurred in all three stocks, and for comparable depressions of oxygen consumptions, the rate of recovery is comparable in the three stocks. This indicates that the differences in the oxygen-consumption depression in the three stocks, in the interval 2 to 4 hours after exposure to the same concentration of hydrocyanic acid, are due to differences in the degree of depression during the fumigation, and not to differences in the rate of recovery from the same degree of depression.

A few tests were made following 40-minute exposures to determine whether the results were similar to those in which the exposures was for 10 minutes. The 40-minute exposures reduced oxygen uptake more than exposures of 10 minutes at the same concentration, but the difference between strains was similar to that found for 10-minute exposures.

These data indicate that resistance to hydrocyanic acid is correlated with the ability of the strains to consume oxygen after exposure to hydrocyanic acid; the greater the resistance of the strain, the higher its oxygen consumption after treatment with hydrocyanic acid. It seems probable then, that the sensitivity of the various strains of red scale to hydrocyanic acid is associated with their dependence on a metallo-enzyme-containing respiratory system. The resistant forms must depend to a lesser extent on these enzymes, and to a greater extent on such oxidative enzyme pathways as the metal-free, autoxidizable, flavoprotein enzymes. The findings of Haas (1934) are of interest at this point because he showed that a low content of copper was associated with resistance to cyanide but failed to find a difference in the iron content of the resistant and nonresistant strains. Copper is recognized as important in protoplasmic oxidation as is iron. Tyrosinase of grasshopper eggs contains copper according to Allen and Bodine (1941). It is also significant that Lindgren and Sinclair (1944) recovered more hydrocyanic acid from fumigated nonresistant than fumigated resistant scales. It is consistent with the metallo-enzyme explanation to recover more hydrocyanic acid from the nonresistant scales because of the metallic compound formed with hydrocyanic acid.

Respirometer tests were also made to determine the oxidative activities associated with protective stupefaction. Stupefaction reduces the kill and may be produced by prefumigation with a sublethal concentration of hydrocyanic acid prior to fumigation with a normally lethal concentration (Yust, Nelson, and Busbey 1942). These tests were

limited to the super-resistant males. The rate of oxygen consumption was determined after treatments in which scales were prefumigated with 0.1 mg. per liter for 10 minutes prior to treatments with 1.0 and 2.0 mg. per liter for 10 minutes. With both concentrations the average rate of oxygen uptake was higher for the scales in which there was protective stupefaction, but the differences were not statistically significant. Thus this set of experiments again suggests that an increase in resistance (by stupefaction) is associated with a higher level of oxygen consumption in comparison with less resistant forms, non-stupefied forms in this case.

TABLE II

MORTALITY OF NONRESISTANT, RESISTANT AND SUPER-RESISTANT STOCKS OF CALIFORNIA RED SCALES IN THE SECOND MOLT AND MALE STAGES FROM EXPOSURE IN AN ATMOSPHERE NEARLY DEVOID OF OXYGEN

EXPOSURE PERIOD, hours	MORTALITY, PERCENT		
	Nonresistant	Resistant	Super-Resistant
Males			
6	40.9	46.7	54.4
9	70.2	70.7	86.5
13	91.8	93.1	98.8
18	98.6	99.0	100.0
Second Molts			
6	15.4	46.2	33.8
9	51.3	80.9	83.2
13	65.4	90.4	98.7
18	88.2	98.0	99.7

Mortalities: In an attempt to express the oxygen consumption-hydrocyanic acid resistance relationship in a more quantitative form, dosage-mortality tests were made and the results were compared with the oxygen-consumption figures following exposure to hydrocyanic acid. Each of the three stocks was fumigated with a series of concentrations for 40 minutes at 25° C. on two dates. Scales of the same stock on six or more fruits were treated with each concentration when they were 19 and 20 days old and 50 insects were counted on each fruit. The LD-50 values for the nonresistant, resistant, and super-resistant stocks were 0.012, 0.21 and 1.05 mg. per liter, respectively. The ratio of the LD-50's for the nonresistant and super-resistant stocks is comparable to the difference in oxygen uptake after exposure to hydrocyanic acid. When the resistant and super-resistant stocks are compared, the difference in LD-50's was less than the difference in oxygen uptake. Because of the extremely large number of oxygen-consumption determinations required, it was considered impractical to collect sufficient data to prove a constant ratio between percent mortality and percent depression of oxygen consumption following exposure to hydrocyanic acid.

Tolerance to Anoxia: Despite the strong presumptive evidence that resistance to hydrocyanic acid is related to the presence of metal-free respiratory enzyme systems, the possibility existed that the resistant strains might be more resistant because their tissues were better able to withstand anoxia regardless of whether it is anoxic or histotoxic in nature. This possibility was investigated by exposing the insects to an oxygen-deficient atmosphere for varying periods of time and determining the consequent mortality.

Scales of the three stocks on lemon fruits were placed in chambers through which nitrogen was flushed continuously for periods of 6, 9, 13, and 18 hours. The exposures were made at room temperature, which was about 25° C. Female scales in the second molt and male scales that were 20 days old were tested. Each mortality is based on 900 insects. The results are given in table II.

The scales that were nonresistant to hydrocyanic acid were most difficult to kill in the oxygen-deficient atmosphere, and the pattern of resistance to anoxic anoxia was the reverse of that to hydrocyanic acid. This situation existed for both males and females, although the difference in the response of nonresistant and resistant males was small. The highest kill was present among the super-resistant males, which are most resistant to hydrocyanic acid. In other tests with mature females and with 19, 20, and 21-day-old second molts, similar results were obtained. The data further confirm the enzyme explanation of resistance. This explanation would also have been in harmony with the data if the kills had been the same for the stocks. It should be noted that Lindgren and Sinclair (1944) report no difference between mature females of nonresistant and resistant races of California red scales in tolerance to lack of oxygen, although they gave no data to support this statement.

The higher survival of the nonresistant scales in the nearly oxygen-free atmosphere would seem to indicate an oxidative system in that strain which is more effective than that of the resistant strain in operating at low partial pressures of oxygen. Warburg and Christian (1932) and Theorell (1936) have indicated the ineffectiveness of the autoxidation of the flavoprotein enzymes at low oxygen tensions. In view of this, it is not surprising to find the hydrocyanic acid-resistant strain highly susceptible to anoxic conditions, since its resistence to cyanide is probably due to its greater dependence on enzymes that operate poorly at low oxygen tensions.

Resistance to Hydrogen Sulfide: As a further test of the involvement of metallo-enzymes in hydrocyanic acid sensitivity, the resistance of the three strains to hydrogen sulfide was determined, since this gas also combines with the metals of the oxidizing enzymes, and thus inactivates them. Nine infested fruits were fumigated in a desiccator jar simultaneously, three fruits being infested with scales of each stock. The treatments were duplicated on the same day and were made at room temperatures ranging from 24.5° to 25.5° C. The gas concentrations were 1, 2, 3, and 4 percent by volume, and the exposure period was 40 minutes. Each mortality is based on 600 insects. The results are given in table III.

The same pattern of resistance is evident with both hydrocyanic acid and hydrogen sulfide. Similar results were obtained in preliminary experiments. This is the only clear manifestation of resistance toward a gas other than hydrocyanic acid in the resistant stocks. The results give added weight to the enzyme explanation of resistance.

TABLE III

MORTALITY OF NONRESISTANT, RESISTANT, AND SUPER-RESISTANT STOCKS OF CALIFORNIA RED SCALE FUMIGATED WITH HYDROGEN SULFIDE IN THE SECOND MOLT AND MALE STAGE

CONCENTRATION, Percent by vol.	MORTALITY, PERCENT		
	Nonresistant	Resistant	Super-Resistant
Males			
1	93.7	61.7	36.5
2	98.5	90.7	68.3
3	99.7	97.2	80.7
4	99.7	99.2	95.7
Second Molts			
1	67.8	61.3	16.7
2	95.5	85.2	43.5
3	99.2	93.2	66.3
4	99.5	97.2	85.7

SUMMARY AND CONCLUSIONS

1. Nonresistant and resistant strains of the California red scale, *Aonidiella aurantii* (Mask.), were studied to determine the nature of the physiological basis for variations in resistance to hydrocyanic acid.

2. Nonresistant, resistant, and super-resistant strains of the California red scale under normal conditions show no differences in the rate of oxygen consumption.

3. After exposure to hydrocyanic acid the oxygen consumption is depressed, the degree of depression being greatest in the nonresistant, intermediate in the resistant, and least in the super-resistant strain.

4. The three strains show the same relative pattern of resistance to hydrogen sulfide that they show to hydrocyanic acid. Those strains most resistant to hydrocyanic acid are the most resistant to hydrogen sulfide as determined by mortalities.

5. After exposure to an atmosphere of almost pure nitrogen, the mortality was highest in the strain showing lowest susceptibility to hydrocyanic acid, and lowest in the strain most sensitive to hydrocyanic acid. Thus the pattern of resistance to anoxia is just the reciprocal of the pattern of resistance to hydrocyanic acid.

6. These findings are taken as strong presumptive evidence that susceptibility to hydrocyanic acid is associated with a high degree of dependence on heavy metal-containing enzyme systems for tissue

oxygen requirements, whereas resistance to hydrocyanic acid is associated with a high degree of dependence on metal-free autoxidizable respiratory enzymes, possibly of the flavoprotein type.

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BONNER ZOOLOGISCHE BEITRAGE. Published by the Zoologisches Forsuchungsinstitut and the Museum Alexander Koenig. Heft 1, Jahrgang 1. Bonn, Germany.

The first issue of this new periodical is dated August 25, 1950. According to the foreword, plans for it were being made as early as 1936, but its appearance was delayed by the war and post-war reconstruction problems. It is to appear quarterly, at a price for the annual volume of DM 14 less ten percent. The first issue is well printed, on good paper, with good reproductions of illustrations, and is well edited. It runs to 95 pages. Of its 14 articles, five are primarily of entomological interest, namely: two on Tipulidae (Diptera) by Bernhard Mannheims, one on Libellulinae (Odonata) by Karl F. Buchholz, one on Cupesidae (Coleoptera) by Johannes Klapperich, and one on Hesperidae (Lepidoptera) by Rudolf Mell. In addition, an article by Bernhard Rensch, on the dependence of the size difference of the sexes upon general body size of the species, is of general interest to the entomologist and is exemplified by entomological material. The editor is Dr. Gunther Niethammer, Museum Koenig, Koblenzer Str. 162, Bonn, Germany.

—M. T. J.

REVIEW OF THE GENUS PERILLUS WITH DESCRIPTION OF A NEW SPECIES

(Hemiptera, Pentatomidae)

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The writer's interest in the genus *Perillus* dates back some 37 years when in August, 1913, near Batavia, N. Y., he first observed the red and black male of *Perillus bioculatus* Fab. mating with the white and black female form, *clanda* Say. There followed three years of breeding work to learn something of how color pattern might be inherited in this species. This involved a detailed study of the biology of this species, results of which came to publication in 1923. At the close of World War I the writer moved to the University of Minnesota where research on the nature of color in Hemiptera was resumed under favorable circumstances. This work culminated in the publication of results, with a colored plate (Knight, 1924). Briefly, this work showed that *Perillus bioculatus* Fab. is highly variable in color pattern, ranging from the white and black *clanda* Say to nearly solid black males in the extreme dark forms. It was found the color forms are not controlled by genetic inheritance, but are the result of ecological factors, particularly temperature which regulates physiological activity, and determines how much pigment will be deposited in the hypodermis and cuticula. At higher temperatures the lighter color patterns prevail as a result of oxidation of pigments at the higher metabolic rate, whereas with temperatures below the optimum rate, metabolism is slowed down so excess pigment coming with the food cannot be eliminated by oxidation, but is deposited in the hypodermis and cuticula.

Perillus bioculatus Fab.

This species feeds almost exclusively on the Colorado potato beetle; in fact east of Colorado it is known to feed only on *Leptinotarsa*. It is of interest to know what *bioculatus* may feed upon in Arizona, California and Oregon where specimens have been collected. This species normally produces two generations each summer, but in rearing cages it will develop a third generation when food is provided.

We have identified the following specimens which are of interest for indicating the extent of distribution for *bioculatus:* ARIZONA: ♂ Aug. 16, 1950, Atascosa Mt., Santa Cruz Co.; ♂ August 19, 1950, Pategonia (R. S. Beal). CALIFORNIA: ♂ ♀ June 20, 1937, Lone Pine, Inyo Co. (Frazier); ♂ Oct. 7, 1948, Dos Palos, Merced Co., (C. A. Hanson); ♀ June 22, 1930, Hamilton (David Damon). OREGON: ♀ May, 1936, Corvallis; ♂ 3♀ June 23, 1947, The Dalles (David & Hammond).

Distant (1880) gives a good illustration of *P. virgatus* Stal which is not distinguishable from *bioculatus* Fab., color form *clanda* Say.

Perillus splendidus Uhler (1861)

This species was described with type from California, and later, Uhler (1876) reported it from Texas and (1894) from lower California. We have recognized this species from California specimens only; they look like red and black or yellow and black ***bioculatus*** but the pronotum and scutellum more densely punctate, having about double the number of punctures found in ***bioculatus***. We are indebted to Dr. R. L. Usinger for the privilege of examining some forty specimens of Perillus and identify *P. splendidus* from California localities as follows: Lebec, Claremont, Kernville, Newport Bay, Santa Ana, Lassen Co., Inyo Co., and San Jacinto Mts.

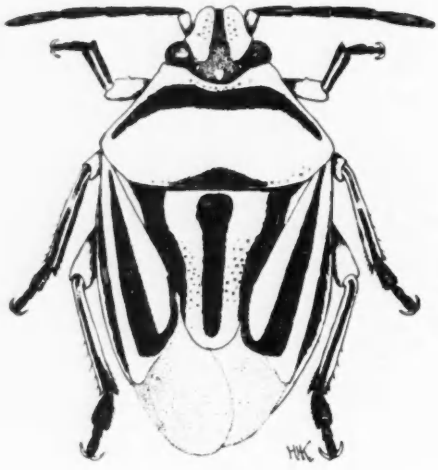

FIG. 1. *Perillus lunatus* n. sp.

Perillus lunatus new species

Allied to *bioculatus* Fab. and resembles the white and black form *clanda* Say, but smaller in size. Distinguished by the lunate black mark on anterior half of pronotum, the slender longitudinal black mark on scutellum, black stripes on tibiae unbroken by bands, uniformly yellowish femora, and abdominal spiracles not surrounded by a black spot.

Male.—Length 7.6 mm., width of pronotum at base 4.4 mm. Head: width across eyes 1.8 mm.; yellowish, vertex except small spot at middle, frons and tylus black, eyes brown. Antennae: segment I, length 0.39 mm., yellow; II, 0.78 mm.; III, 0.74 mm.; IV, 0.86 mm.; V, 1.00 mm., last four segments black, clothed with fine, short pale pubescence. Rostrum, length 2.25 mm., reaching to middle of intermediate coxae, yellowish, two apical segments blackish. Ventral surface of juga more sharply tumid than in *bioculatus*. Pronotum:

length, base to anterior angles 2.42 mm., widest at base 4.4 mm.; strong punctures moderately spaced. Color pale yellowish to orange, a large lunate mark on anterior half of disk, and area on middle of basal margin, black (fig. 1). Propleura with black line beneath and parallel to dorsal margin, at middle extending down to coxal cleft. Scutellum pale yellowish, basal half with hypodermal color showing orange, lateral margins and median stripe black; the median vitta more slender than found in *bioculatus*. Corium white, central area with wedge of black; membrane rather evenly fuscous. Legs pale to yellow, femora without black, tibiae black, with two longitudinal white stripes, one on each dorsal edge, not broken into bands as in *bioculatus*. Venter yellowish to orange, first segment black behind coxae, joining a sublateral line which forms beneath the spiracles, and last three segments more broadly black on median area. Spiracles not inclosed by black spots. Genital segment showing slight but distinct differences from *bioculatus*.

Female. Length 7.8 mm., width of pronotum at base 4.6 mm. Color pattern very similar to the male. The white discal area of pronotum, basal area of scutellum, each side of tylus, central area of pleural sclerites, and central area of the venter, showing an accumulation of orange to reddish pigment in hypodermis. Color of tibiae as in the male.

Holotype: ♂ August 22, 1925, along highway some ten miles east of Pingree Park, COLORADO, altitude near 7,000 ft. (H. H. Knight); author's collection. *Allotype:* female "Colorado," an old specimen. In previous years we have seen two or three odd specimens in collections, mixed in with *bioculatus*. Apparently a species of the higher altitudes in Colorado and scarce in collections.

Perillus circumcinctus Stal (1862)

The type locality for this species is uncertain, the original citation given as "Mexico?". We know *circumcinctus* as a boreal species, extending from Missouri, Nebraska to Ontario, Can., and eastward. In Minnesota we found it feeding on the goldenrod beetle (*Trirhabda canadensis* Kirby) and specimens we reared refused to feed on *Leptinotarsa*. Specimens reared to adults in July refused to continue with a second generation even when surrounded with their favorite food. Reared specimens went into aestivation early in August and then to hibernation for the winter. As mentioned by Van Duzee, we find little variation in the color pattern. The pronotum is more elongated than in *bioculatus*, with the bronzy brown color very distinctive, the legs uniformly brown except for an incomplete white band at middle of tibiae.

Distant (1880) figures a nearly black specimen of *Perillus* and refers it to *circumcinctus* Stal; very evidently an error in identification.

Perillus exaptus (Say) 1825

This small species varies greatly in color as does *bioculatus*, and in the northern part of its range becomes almost entirely black. We have noticed some variation in length of antennal segments and other characteristics, but believe the complex is an interbreeding population.

Perillus confluens (H. S.) 1839

This species is known from Texas, Colorado, Arizona, and southward. Dr. H. M. Harris collected specimens in Guatemala which were feeding on a species of *Leptinotarsa*. *P. confluens* resembles *Mineus strigipes* in coloration but does not have the median yellow stripe on pronotum, and differs structurally in having the tubercle on front femora which distinguishes the genus.

KEY TO SPECIES OF PERILLUS

1. Pronotum distinctly convex on basal submargin, raised distinctly above level of scutellum; paler margin of scutellum not extending as a distinct band of color across black of the pronotum 2
   Pronotum somewhat depressed or flattened on basal submargin, scarcely elevated above level of the scutellum; scutellum with marginal orange color extending as a continuous band upon the black pronotum ..... **confluens**
2. Pronotum without a lunate black mark on anterior half; scutellum black or with a median black mark which is distinctly broader at base and usually bifid 3
   Pronotum with a large lunate black mark on anterior half; scutellum with slender mesal black stripe which is only very slightly broader at base; tibiae pale, with longitudinal black stripes unbroken by cross bands ..... **lunatus**
3. Abdominal spiracles inclosed by black, sometimes by black spots; second antennal segment black or partly black 4
   Abdominal spiracles not inclosed by black; first and second antennal segments golden brown; all dark areas tinged with bronze ..... **circumcinctus**
4. Front femur with a distinct subapical spine; larger, length over 7.5 mm 5
   Front femur with a blunt subapical tubercle in place of a spine; smaller, length not over 7.5 mm ..... **exaptus**
5. Pronotum and scutellum rather uniformly and closely punctate ..... **splendidus**
   Pronotum and scutellum more sparsely punctate, leaving open space where many punctures could fit in ..... **bioculatus**

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STUDIES OF AN INSECT MYCOSIS

III. HISTOPATHOLOGY OF AN ASPERGILLOSIS OF PLATYSAMIA CECROPIA L.[1]

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Previous papers in this series have discussed the etiology and host-parasite ranges of a disease of the cecropia moth, *Platysamia cecropia* L., caused by the fungus, *Aspergillus flavus* Link (Sussman 1951 a, b). The effect of the parasite upon the tissues of the host and its method of entrance and attack will now be reported.

MATERIALS AND METHODS

The histopathology of this disease was investigated by the following techniques: (1) Direct examination of the unstained tissues "*in vivo*," (2) Examination of stained tease mounts, and (3) Examination of sectioned material.

"*In vivo*" examination was possible only in the case of pupae where it was possible to attach a posterior cellophane window. The methods used in preparing such animals have been discussed in previous papers (Williams 1946; Sussman 1951 a). Figure 1 illustrates a brainless diapausing animal prepared by these methods, while figure 2 shows how direct observation of the progress of infection is made possible by means of the plastic window. The penetration of the parasite into the insect's hemocoele was observed microscopically by the use of incident lighting supplied by an ordinary lamp or by the use of a Leitz Ultropak.

Tease mounts of tissues from infected animals were observed after staining with toluidine blue. This method was used only when details of organization of the host's tissues were not required.

Finally, sectioning was accomplished by the use of paraffin and celloidin embedding techniques. So that penetration would not be delayed, infected larvae were fixed in hot (70° C.) Bouin's and immediately evacuated. After fixation the material was thoroughly washed in 50% alcohol and dehydrated. Some first instar larvae were cleared in chloroform and embedded in paraffin, but the bulk of the material was infiltrated with celloidin, as suggested by Lefebvre (1934), who used Wetmore's (1932) and Jeffrey's (1929) techniques. In order to insure effective penetration of the celloidin, the tissue was completely dehydrated and run up through a series of ether-alcohol-parlodion mixtures which were kept in a 59° C. incubator. The material was softened and its sectioning qualities improved by storage in glycerin-

[1]Portion of a thesis presented in partial fulfillment of the degree of Doctor of Philosophy at Harvard University.

The author would like to express his gratitude to Dr. William H. Weston for his sympathetic and stimulating direction of this work. Thanks are also due to Dr. Carroll M. Williams for his cooperation and suggestions.

alcohol after preliminary hardening in chloroform. Mallory's triple stain was used for gross differentiation of host and fungus tissue, while cytological details were investigated by use of Heidenhains' hematoxylin and eosin. In this way, shrinkage of soft inner tissues away from the sclerotized outer tissues was minimized.

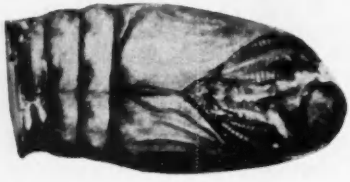


FIG 1

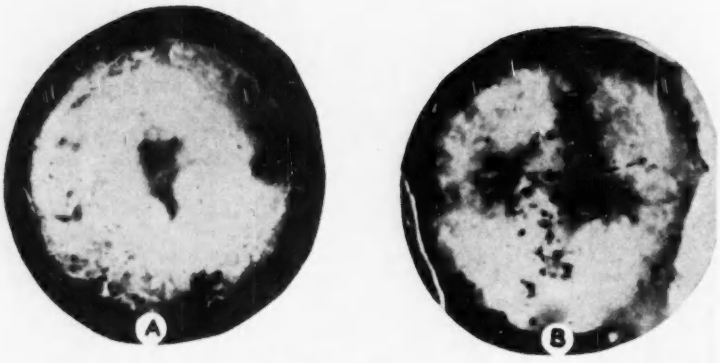


FIG 2

FIG. 1. Brainless diapausing pupae of *Platysamia cecropia* with window prepared according to Williams (1946). Mag. 2½×.

FIG. 2. Comparison of the appearance of the interior of healthy and infected pupae of *P. cecropia* seen through posterior windows.A. Healthy animal showing the yellowish unspotted lobes of the fat body. B. Animal infected by injection of spores of *A. flavus* after 24 hours. Note the spots which have appeared on the fat lobes. These animals have been treated with phenylthiourea in order to prevent darkening of the blood. Mag. 4 ×.

Infection of larvae was accomplished by spraying aqueous suspensions of spores over their integument while pupae were injected with suspensions in the manner described in a previous paper (Sussman 1951 a).

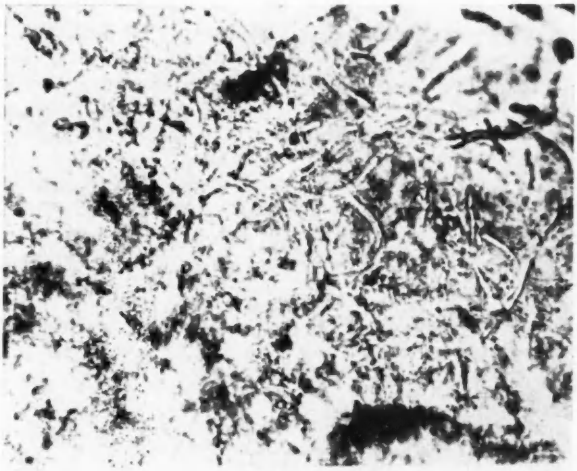


FIG 3

FIG 4

Tease mounts of tissues of larvae of *P. cecropia* infected by dusting spores of *A. flavus* over the animal's integument four days previous to examination.

FIG. 3. Gonad. Note how the fungous hyphae have overrun the entire tissue. Mag. 1200 X.

FIG. 4. Head of larva. Note the manner in which the epithelium underlying the integument has been invaded by the pathogen. The conidial heads, indicated by the arrow, were produced outside the animal. Mag. 300 ×.

Special techniques were required for the observation of the effect of the parasite on the host's blood. For this purpose, tissue cultures of blood were prepared. The culture medium used was Locke's solution, as described by Glaser (1917). The blood had to be obtained as aseptically as possible, so all operations were conducted in a steamed transfer chamber to prevent chance contamination. Moreover, in order to insure sterility, all dissecting instruments were sterilized in 70% alcohol and the excess burned off. Before any blood was extracted the animal's integument was swabbed with 70% alcohol. A few drops of blood were then removed and placed on a sterile cover slip in the center of which a few drops of sterile Locke's solution were placed. Inoculation was accomplished by introducing spores of the fungus at this point. The cover slip was quickly inverted and placed on a depression slide which had been sterilized and was contained in a Petri dish. Finally, the cover slip was sealed with a ring of vaseline in order to minimize evaporation and contamination. The blood suspended in Locke's solution could then be observed directly through the microscope.

For the observation of phagocytosis, it was found that the use of mineral oil as a suspending medium for blood gave the best results (Yeager 1938). In this method, a drop of mineral oil is placed on a clean slide and the blood is suspended in the oil and examined directly with an oil immersion lens.

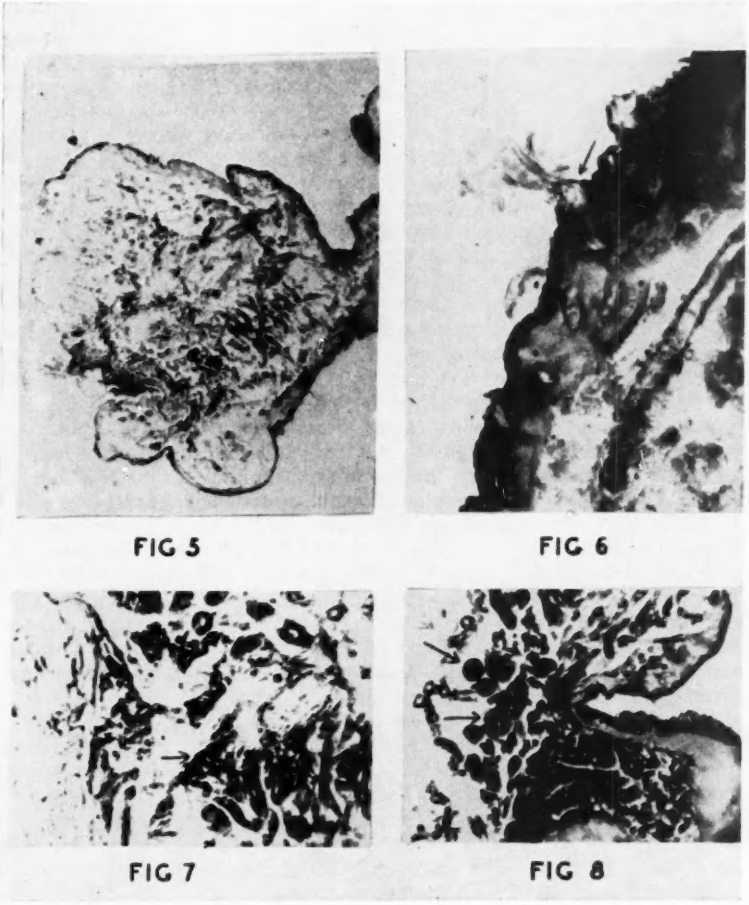
Cytological details of the hemocytes were investigated by the use of the smear technique, as outlined by Yeager (1945, 1938). Animals whose blood was to be used were placed in water kept at 55–60° C. for 10 minutes so as to fix the blood cells in the "passive" state. Blood smears were made in the usual way and were air dried. These were flooded with undiluted Wright's stain for 1½ minutes and were then diluted with an equal volume of aqueous 2½% nicotine, freshly prepared. The smear was then washed and immediately blotted and dried carefully over a small flame. It was then dipped twice in 70% alcohol until the right amount of dye was removed, whereupon the smear was again blotted and carefully dried over a flame. Finally, the slide was flooded with 0.0006% oxalic acid solution in distilled water for 1 to 2 minutes, blotted and dried as before, and mounted permanently in balsam.

HISTOLOGY OF THE LARVAL INFECTION

Preliminary observations of the course of infection were made by means of tease-mounts. It was hoped to obtain information as to the kinds of tissues invaded and the readiness with which different tissues submitted to invasion by the pathogen. Larvae which had been infected two days previously were cut open and their tissues examined. It can be seen from figure 3 and 4 that most of the gonad tissue was penetrated by the pathogen, while the epithelium underlying the integument was also invaded. Conidiophores shown in figure 4 were only produced outside the animal since it has never been possible to find fruiting occurring in the body cavity.

More detailed observation of the course of disease were carried out using serial sections of naturally infected animals. Slides prepared by

sectioning animals show that ultimately every tissue of the larva is penetrated by the fungus (fig. 5), except the sclerotized epicuticle. The fat body is penetrated first and is rapidly disintegrated by the



Transverse sections of 1st instar larvae of *P. cecropia* infected for four days with *A. flavus*.

FIG. 5. Abdomen of animal showing the complete disintegration of tissue attacked by the pathogen. Mag. 120 ×.

FIG. 6. Portion of abdomen of animal showing penetration of endocuticle. Note how epidermal hair at arrow has been broken down by the fungus. Mag. 2500 X.

FIG. 7. Portion of abdomen showing gut and muscular elements being penetrated by fungous hyphae. Mag. 800 ×.

FIG. 8. Similar to fig. 7, except that muscular elements designated by arrows are seen to be almost intact despite the disintegration of the surrounding tissues. Mag. 800 ×.

pathogen. Even the endocuticle (fig. 6) is invaded, as is the chitinous lining of the hind gut (fig. 7). However, it is to be noted that hyphae are much more abundant in the integument and are sparser in the gut which is penetrated later than the other tissues. One other tissue displays surprising resistance to the spread of the fungous hyphae, namely, the muscular elements, as figure 8 demonstrates. Thus, the muscle tissue retains its identity and is relatively free of fungous hyphae despite the fact that the surrounding tissues are riddled with the fungus and later disintegrated by it.

It can also be seen in figure 9 that there is considerable variation in the size of the hyphae of *A. flavus* in the different tissues of the larva of *P. cecropia*. As a rule, the hyphae are larger in size in the fatty tissue than in most of the other tissues.

It is apparent that all the tissues of *Platysamia cecropia* larvae, except the epicuticular, are attacked by *Aspergillus flavus*. However, there is a definite differential in the speed with which the fungus can penetrate and disintegrate the various tissues. The fat body seems to be the most readily invaded and broken down of all the tissues but, in contrast, the muscular elements resist invasion until the infection is far advanced. Figure 8 demonstrates the resistance of the insect's muscular tissue to decomposition by the fungus. Although the surrounding tissues are rather extensively invaded by fungous hyphae, the muscle tissue seems to be almost intact, although a few hyphae may be discerned within the tissue. Burnside (1930) claimed that the thoracic musculature was a favorite place for the growth of *Aspergillus flavus* in the honey bee. However, Lefebvre (1934) and Wallengren and Johansson (1929) observed that the corn borer's muscular tissue was quite resistant to penetration by the fungi with which they worked, while Gee and Massey (1912) suggested similar findings as a result of their work with aspergilli infecting bees. It is probable that the time of observation may have something to do with this discrepancy since the musculature is eventually attacked by the fungus, but only after most of the other tissues have been devoured.

The fact that larvae can be infected by dusting spores over its integument raises the question as to whether or not it is possible for the fungus to penetrate the integument. Figure 10 gives histological evidence to suggest the ability of *A. flavus* to penetrate the integument by way of the membranous portion of the tubercles. However, it is likely that the fungus also enters via the digestive tract since it was noted that the bulk of the infection started from the digestive tract of the animals sectioned. This suggests that the animal was infected by passage of spores through the mouth or anus, into the digestive tract, whence the fungus spread into the posterior portion of the body cavity. Figure 7 shows the penetration of the chitinous lining of the hind gut by the fungus and the subsequent penetration into the softer tissues of the insect.

That the aspergilli can penetrate insects in both ways is proven by the work of other investigators. For example, Metalnikov and Toumanoff (1928), Toumanoff (1928) and Lepesme (1939) showed that *A. flavus* entered the integument of corn borer larvae and the thoracic stigmata (tubercles) of crickets. Similarly, Blochwitz (1929) claims that *A.*

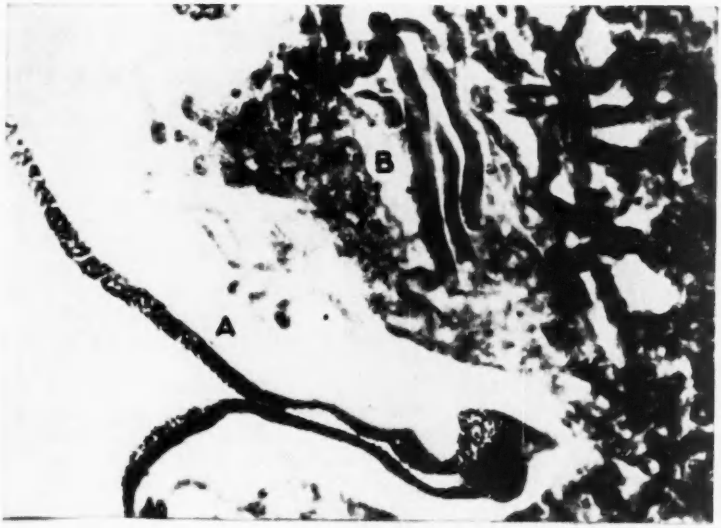


FIG 9

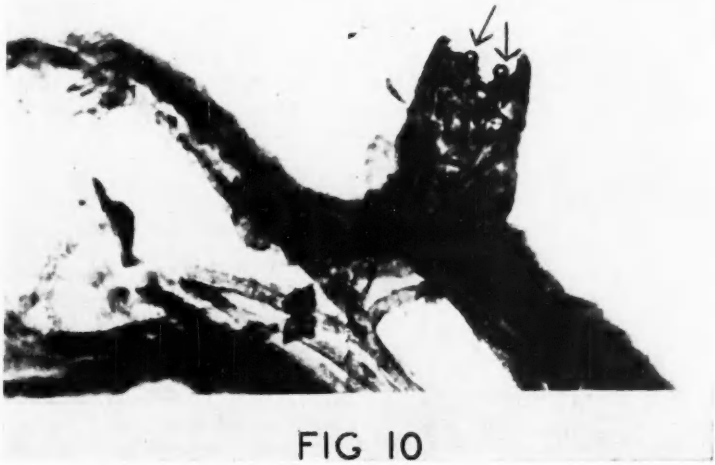


FIG 10

FIG. 9. Cross section through part of the integument and fat body of a larva of *Platysamia cecropia* infected with *Aspergillus flavus* four days previous to examination. Note the differences in size of hyphae of *A. flavus* as it penetrates various tissues. A. Endocuticular tissue. B. Fat body. Mag. 3000 ×.

FIG. 10. Section of integument of *P. cecropia* larva over which spores of *A. flavus* had been dusted 2 days previous to examination. Note spores at arrow germinating and gaining entrance to the body cavity through a tubercle on the animal's integument. Mag. 1000 X.

clavatus Desm. grew down the stigmata and through the articulations of integument of *Drosophila*. Using another fungus, *Metarrhizium anisopliae* (Metch.) Sor., Wallengren and Johansson (1929) found that the parasite could penetrate through the pyramidal pigment areas of the corn borer. On the other hand, *A. niger* van Tieghem and *A. glaucus* Link produce a lethal gut infection in mosquitoes (Galli-Valerio and Rochaz-De Jong 1905); and Vincens (1923) and Burnside (1930) found it possible to infect bees with certain species of Aspergillus by feeding them honey in which spores had been placed. More recently, Cury (1946) noted that *A. flavus* invades the stomach, intestines and body cavity of the bee, again suggesting that infection occurred via the digestive tract.

Therefore, although there is evidence for the direct penetration of the body wall of insects by the aspergilli, it is by no means certain that infections occur most commonly by this means. It is likely that the conidia of aspergilli can penetrate the less sclerotized portions of tubercles and the articulations of the exoskeleton. However, for this to happen on the surface of the animal requires rather special conditions of temperature and humidity. In contrast, in the digestive tract these conditions are much more easily met, so that it would appear that entering via the digestive tract would afford the easiest means of access for the pathogen.

HISTOLOGY OF THE PUPAL INFECTION

The course of spore germination and development within the insect's body cavity was followed in animals with posterior windows. By this means it was seen that the fungus penetrated the fat body as soon as it began to grow.

Dissections made 24 hours after infection have shown that black pigmented areas occur in the focus of an infection, suggesting melanin formation in parasitized tissues (Cameron 1934). Figure 2 illustrates the appearance of tissue attacked by the fungus after 24 hours of infection.

Slides prepared by sectioning diseased pupae parallel the results obtained with larvae. Animals which were inoculated and fixed after incubation 24 hours at room temperature showed that germination of spores was already far advanced, and that the fungus rapidly spread through the fat body. Epithelial tissues, muscle and endocuticle were attacked only after 48 hours until finally, at the end of 72 hours, most of the animal was riddled with fungous hyphae.

THE EFFECT OF THE PATHOGEN UPON THE HOST'S BLOOD

Observations of infected pupae with posterior windows show that the fungus germinates in the body cavity within 8 hours after inoculation and incubation at room temperature. Upon germination, the fungus spreads through the body cavity by means of mycelium that is typical in every respect except that the hyphae become brown in color. In about 36 hours, elements of hyphae begin to attack tissues of the body other than the blood, and may be traced for some distance in their course through the body cavity. Observation of the hyphae is easily made since they have a characteristic shining silvery appearance in

reflected light; tracheae have the same appearance but may be differentiated from hyphae by their greater size. However, with the continued proliferation of the fungus throughout the insect's body cavity, observation is rendered more difficult. Finally, after about 72 to 96 hours,

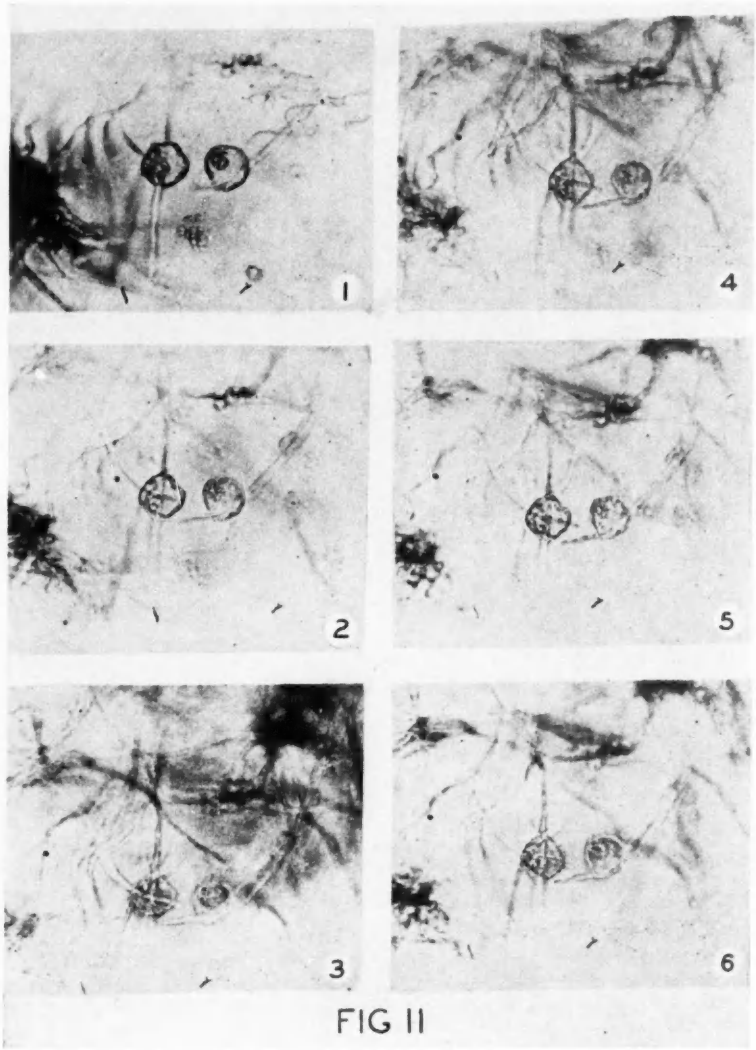


FIG. 11. Tissue culture of blood of larva of *P. cecropia* inoculated with spores of *A. flavus*. Photographs taken at two-hour intervals. Note penetration of blood cells (designated by arrows) by hyphae of fungus. Mag. 1000 ×.

so much of the interior of the animal is filled with mycelium and regenerating epithelium that it becomes impossible to discern much detail by the use of this method of observation.

Tissue culture techniques were also used in the study of both larval and pupal blood. By this means, blood cells were kept alive and, in some cases, dividing for almost a month. In the case of larval blood, 25 different larvae of *P. cecropia* were used, and slides in triplicate were made from each animal. These slides were prepared as has been

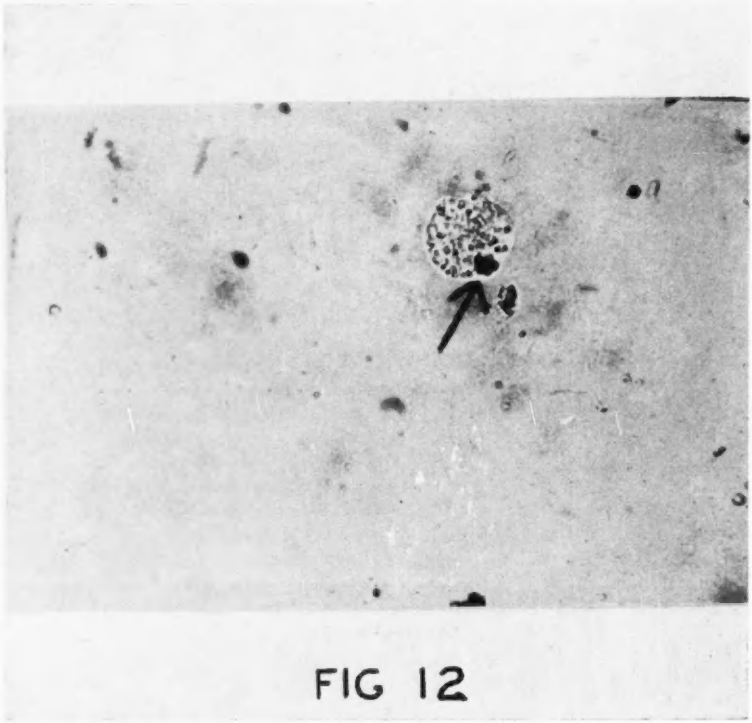


FIG. 12. Blood cell of *P. cecropia* removed from animal 60 minutes after injection of spores of *A. niger* and mounted in mineral oil, showing phagocytosis of a group of spores. Mag. 1200 ×.

outlined in the section on methods. One of the slides of each set was used as a control and was not inoculated. Periodic observations of these slides were made and photographs were made at appropriate intervals. Observation showed that the fungus attacked blood cells which soon lost their regular outline, while their contents became more granular and were finally lysed (*cf.* fig. 11).

In order to determine what defense could be mobilized against fungous infection, an investigation of phagocytosis in the animal's

blood was undertaken. Spores of *A. flavus*, a species known to be parasitic, were injected into previously chilled diapausing animals. For comparison, spores of *A. niger*, a species known to be non-pathogenic, were also used as inoculum. The latter species has characteristic black warty spores which are easily distinguishable among blood cells. Samples of the blood of inoculated animals were taken 15, 30, 45, 60 and 120 minutes after injection and mounted in mineral oil, while duplicates were stained with Wright's Stain as previously described. In addition, by the use of the above techniques, the blood of these animals was inspected daily for a week after infection.

In the case of animals infected with *A. flavus*, it was apparent that a few spores were engulfed by phagocytes in the insect's blood, within 30 minutes after their introduction. Although the amount of leucocytes in the animal's blood increased steadily upon infection, the pathogen was able to grow and spread throughout the insect. At the end of two days' infection, the blood became filled with fat droplets and tissue debris, while the leucocyte count rapidly decreased. Finally, the blood turned coffee brown and the animal ceased all movements of its abdomen.

On the other hand, in those animals inoculated with *A. niger*, phagocytosis of spores was more frequently encountered (fig. 12) than in the case of those animals inoculated with *A. flavus*. Moreover, the sharp rise in the number of leucocytes in the blood was observed to continue for two days after inoculation and began to drop off only after the third. Although some fat droplets were observed in the blood, there was little tissue debris, and the color remained yellowish green. Phagocytosis was observed to continue for 4 days after incoculation and at the end of this time ungerminated spores of *A. niger* were still found free in the blood. However, despite the presence of these spores, the animal showed no apparent ill effects and matured normally.

DISCUSSION

There is still not complete agreement as to the importance of phagocytosis in the resistance of animals to fungous infections. For example, phagocytosis was observed in the case of spores of a fungus related to *Oidium* in the sandhopper, *Talitrus* (Hermann and Canu 1891), and in the case of *Saccharomyces cerevisiae* Hans., *S. pastorianus* Hans., and other non-pathogenic yeasts injected into guinea pigs and rabbits (Skšivan 1899; Schattenfroh 1896). De Bary (1887) even claimed to have seen the phagocytosis of hyphae of *Cordyceps militaris* (Fries) Link by leucocytes of the larvae of certain Sphynx moths, as illustrated by his Figure Cd, on page 371. More recently, Boczkowska (1935) has shown that "giant cells" (Metalnikov 1926), or agglomerations of leucocytes, are formed in insects as a defense against fungous infection.

On the other hand, Metchnikoff (1893) stated that in most cases mycelial filaments and conidia develop in the blood without much hindrance. This was shown to be true for a disease of the bettle, *Cleonus punctiventris* Germ., caused by *Metarrhizium anisopliae* (Metch.) Sor. and for diseases caused by *Saprolegnia*. Skšivan (1899) also showed this to be true in the case of the pathogenic yeasts which he injected into guinea pigs.

Thus, it seems to follow that in the fungous infections investigated phagocytosis is important in preventing the successful attack of non-pathogenic forms, but offers little or no obstacle to the pathogenic ones.

The writer's results are in agreement with this interpretation up to a certain point. It was found, for example, that although spores of *A. flavus*, a virulent pathogen, were able to produce fatal infections in the cecropia moth, some evidence of phagocytosis was discovered. Moreover, despite the fact that spores of the non-pathogenic species tested, *A. niger*, were also shown to be phagocytised, ungerminated spores of this fungus were found free in the blood 4 days after inoculation. It is probable, then, that factors other than phagocytosis, such as substances in the blood which prevent germination, are operative in the animal's defense against fungous infection.

GENERAL CONCLUSIONS

From the foregoing, it is suggested that the progress of the invasion of *Platysamia cecropia* by *Aspergillus flavus* is as follows. The pathogen, in most cases, enters the animal through the gastrointestinal tract, although it is possible for infection to occur by way of the integument, through the intersegmental membranes. Upon gaining entrance, the fungus first attacks the fat body of the insect and spreads extensively through this tissue, even before it begins to attack the other tissues (fig. 8). Meanwhile, the animal's movements become spasmodic and it stops feeding. Complete consumption of the fat body is achieved by the fungus whereupon the area formerly occupied by this tissue is entirely overrun by mycelial growth. Meanwhile, the glandular elements and the endocuticular tissues are attacked and broken down by the pathogen and the animals voids liquid feces and develops black spots on its integument. Finally, the fungus becomes established in the tracheae, muscles and tissues of the gut, whereupon the animal is completely riddled with fungous mycelium. By this time the animal has ceased all movement and has become limp and flaccid, after which the green fruiting bodies of the fungus make their appearance and cover the dead insect's body.

SUMMARY

1. The sequence in which tissues of pupae and larvae of *Platysamia cecropia* are attacked by the fungus *Aspergillus flavus* is described.

2. Phagocytosis of spores by blood cells is shown to occur but is found not to be effective in overcoming an infection by *A. flavus*.

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ON THE CLASSIFICATION OF THE HESPERIIDAE[1]

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The Hesperioidea have always presented difficulties to anyone who attempts to arrange a system of classification for them. Their remarkable uniformity of structure leaves us with so little upon which to base sound distinctions that we often are forced to consider significant any trivial character that appears to be a fairly consistent criterion to characterize a group.

In an effort to seek phylogenetic relationships and a natural classification for the "skippers," based as far as possible on rather constant structural peculiarities to characterize subfamilies and tribes, specimens representing all the faunas of the world and many of the previously proposed groups were examined in the following manner. The wings, three legs, palpus, and antenna were removed from the right side of the mounted insect, wetted in alcohol, and thoroughly bleached in one of the commercial solutions of sodium hypochlorite (full strength). They were then rinsed in water, dehydrated in alcohol, and passed through oil bergamot and xylol before being mounted permanently in balsam.

This method produced mounts in which the parts could be examined in considerable detail, the structures and neuration being obscured by no superficial vestiture. While, for example, vein M_2 of the secondary and remnants of the medial stem of both wings were thus rendered somewhat less visible than claimed by authors who have been aided by indications of external scaling, other features became more easily apparent. The armature of the tibiae was much more clearly observed when the finer hairs were made practically invisible by bleaching, leaving only the spines and spurs evident. The relative length of the tarsal joints could be noted with some accuracy, also.

The species examined in the above manner are listed below. All determinations were made by Dr. A. W. Lindsey. The nomenclature follows the two catalogues of Evans, except for the American material; the general locality from which each specimen came is noted in parentheses.

[1]Slightly revised from a paper submitted in partial fulfillment of the requirements for graduation with honors, Denison University, June 12, 1950. Summarized before the Zoology Section, Michigan Academy of Science, Arts, & Letters, East Lansing, March 23, 1951.

[2]I am deeply indebted to Dr. A. W. Lindsey, of Denison University, under whose direction the entire project was carried on, whose personal collection supplied all of the specimens involved in the study, and without whose advice and inspiration the work could never have been completed. The Denison University Research Foundation has also rendered much-appreciated aid in the form of a research grant which has covered the expenses of the project and of publication.

EUSCHEMONINAE
Euschemon rafflesia Macleay (Australia)

COELIADINAE
Coeliades forestan Cramer (Gold Coast)

PYRGINAE
Acolastus amyntas Fabr. (British Honduras)
Bungalotis ramusis Cramer (Peru)
Celaenorrhinus rutilans Mab. (Cameroons)
Celaenorrhinus macrostictus Holl. (Cameroons)
Cogia calchas H.-S. (British Honduras)
Eantis busirus Cramer (Peru)
Epargyreus exadeus Cramer (Peru)
Eudamidas jason Ehrmann (Mexico)
Eudamus simplicius Stoll (British Honduras)
Grynopsis coeleste Doubldy. & Hew. (Peru)
Heliopetes ericetorum Bdv. (California)
Heliopetes petrus Hbn. (Canal Zone)
Netrocoryne repanda Felder (Australia)
Pyrgus communis Grote (Ohio)
Pyrgus syrichtus Fabr. (British Honduras)
Sarangesa brigida Ploetz (Cameroons)
Xenophanes tryxus Cramer (British Honduras)

PYRRHOPYGINAE
Pyrrhopyge pseudohadassa Mab. & Boul. (Peru)

MEGATHYMINAE
Megathymus neumoegeni Edw. (Arizona)

TRAPEZITINAE
Hesperilla crypsargyra Meyr. (Australia)
Hesperilla donnysa Hew. (Australia)
Hesperilla ornata Leach (Australia)
Toxidia peron Latr. (Australia)

HESPERIINAE
Ancyloxypha numitor Fabr. (Ohio)
Baoris fatuellus Hopff. (Cameroons)
Baoris lugens Hopff. (Tanganyika)
Butleria cypria Mab. (Bolivia)
Caenides dacena Hew. (Cameroons)
Calpodes ethlius Cramer (Texas)
Carterocephalus palaemon Pallas (Saskatchewan)
Cephrenes augiades Felder (Australia)
Euroto lyde Godman & Salvin (British Honduras)
Euroto micythus Godman & Salvin (British Honduras)
Hesperia ottoe Edw. (Iowa)
Hesperia sassacus Harris (Virginia)
Hylephila phylaeus Drury (Texas)
Hypoleucis ophiusa Hew. (Cameroons)
Leona maracanda Hew. (Cameroons)
Leona sp. (Cameroons)
Oarisma garita Reak. (Colorado)
Ochlodes sylvanoides Bdv. (Colorado)
Ochlodes venata Bremer & Grey (Manchuria)
Ocybadistes walkeri Heron (Australia)
Oligoria maculata Edw. (Florida)
Pardaleodes reichenowi Ploetz (Cameroons)
Perichares corydon Fabr. (Peru)
Poanes hobomok Harris (Ohio)
Prenes evadnes Cramer (Peru)
Pterotelnon caenira Hew. (Cameroons)
Pyrrhopygopsis orasus Druce (Peru)
Taractrocera anisomorpha Lower (Australia)
Thymelicus sylvatica Bremer (Manchuria)

In addition to the above, numerous other species have been studied without dissection to confirm relationships (as far as was possible by gross examination) suggested by the mounted material. In the analyses of the various subfamilies and tribes, this treatment mentions in their places only those genera representatives of which have actually been examined in one way or another (unless otherwise specified). Likewise, when a correlation exists with differently named categories of other authors, only if actual examination has made the other groups familiar (at least in part) has an indication been made as to what subfamily or tribe is equivalent to them or includes them.

Since it has been possible to examine critically only a very small sample of the genera of the Hesperiidae, it is not impossible that some of the distinguishing characters used here for the first time are capable of more exceptions than may be indicated. The material examined has, however, been sufficient to indicate that some of the characteristics used in the past (as, for example, cell length in the Pyrginae) definitely do not hold for separating major groups, and use of such characteristics is not perpetuated by their repetition in the present diagnoses.

As far as a linear series can express a phylogeny which is at best indicated with difficulty in a two-dimensional diagram, the order of the brief descriptions of subfamilies and tribes will indicate the conclusions of this study. The first paragraph of description generally includes the most important and most consistent distinguishing characters for each group.

A suggested phylogenetic chart for these groups is shown in figure 25. The tribes into which two of the subfamilies are divided have taken their names from the oldest named genus which would be included, and are generally more comprehensive than the various "generic groups" which sometimes have been proposed for the family.

FAMILY HESPERIIDAE

These insects are so uniform that only one family seems necessary for them, although on the other hand they are so distinct from the other Lepidoptera that we recognize the superfamily Hesperioidea, a division equivalent to the Papilionoidea (all other families in the series Rhopalocera of the suborder Frenatae).[3] The superfamily, then, contains this one very well-marked family of usually small, dull-colored, rapid-flying butterflies with rather stout bodies.

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[3]The diurnal habit and clubbed antennae of the skippers show more affinity with the butterflies than with the moths. The presence of 12 unstalked veins and the suspension of the pupa in a light cocoon are intermediate conditions, but would scarcely be adequate basis for recognizing a third group equivalent in status to the Rhopalocera and Heterocera series. Haase (1891, p. 26) proposed the suborder Netrocera for the skippers, and included the one family Hesperiidae. Karsch (1892, p. 177) observed that Haase's name was an unfortunate selection, Netrocera having been used by Felder as a generic name in the Lepidoptera; the next year (1893, p. 169) he suggested the name Grypocera for the suborder designated Netrocera by Haase. Reuter (1897, p. 207 *et passim*) accepts the designation of Karsch, and provides extensive bibliographic references to the classification of the group.

The primaries have twelve veins (fig. 1), all from the base of the wing or from the cell and almost never stalked.[4]

Secondary sexual characteristics on the primaries of the male take two common forms: a fold along the costal margin of the wing, or a stigma of darker (often glandular) scales distal and anal to the cell. The costal fold type occurs only in the Pyrginae; the discal stigma, only in the Trapezitinae and Hesperiinae. Tufts of scales or hairs on the wings and tufts of hair on the tibiae are other secondary characteristics of the males of some species.

The legs are all developed, the front tibiae almost invariably bearing an epiphysis. The hind legs are usually provided with two pairs of tibial spurs, one terminal and the other medial; the mid tibiae bear one

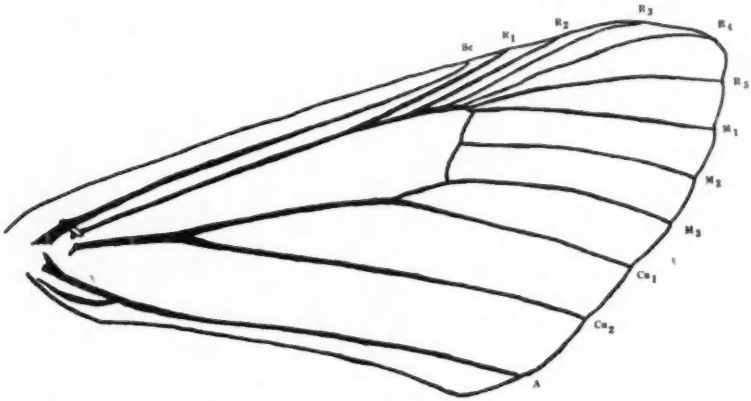


FIG. 1. Venation of primary of *Euschemon rafflesia* ♂. Typical primitive hesperiid venation. Note the retinaculum of this species outlined at bases of subcostal and radius. The veins have been labeled according to the Comstock-Needham system.

terminal pair of spurs. The tibiae may be with or without spines. The fifth joint of the front tarsus is always longer than the fourth joint; that of the mid and hind tarsi usually so. Third tarsal joint of all legs usually longer than the fifth. The antennae are frequently provided with a short, often much constricted point or apiculus at the end of the club.

Subfamily **Euschemoninae**

Male with a well-developed frenulum and retinaculum, and with a brownish-gray brand along the 1st A vein of the under surface of the

[4]A very few anomalous individuals in the Coeliadinae (fig. 4), Pyrrhopyginae, and Megathyminae showing a slight short-stalking were discovered in the course of the present study. Speyer (1879, p. 479, footnote) has called attention to such an abnormality in a specimen of *Oarisma garita*, in which veins M_2 and M_3, were stalked.

secondary. No costal fold nor discal stigma. Antennae very long, with a slender club (over 40 segments) tapering into a long apiculus.

All of the tibiae are spined, the front only slightly so. Front tibiae with a well-developed epiphysis. Mid tibiae with one pair of spurs; hind tibiae with a pair of terminal spurs, the medial pair being short—usually reduced to stubs shorter than the spines—or absent. Fourth tarsal joint shorter than the fifth on front legs, about the length of the fifth on the middle legs, and slightly longer than the fifth on the hind legs.

Vein M_2 of primary intermediate between M_1 and M_3. M_2 of secondary present and tubular throughout. Cu_2 of primary originating closer to base of cubital stem than to origin of Cu_1. No evidence of a medial stem nor a recurrent vein in the cell of either primaries or secondaries. (The venation of the primary is shown in figure 1.)

The subfamily includes but one species, *Euschemon rafflesia*, restricted to Australia. *Euschemon* is sometimes placed in a separate family under the superfamily Hesperioidea, although Evans (1949) and Mabille (1903) have included it in the Pyrginae.

Subfamily **Coeliadinae**

Third joint of the palpus (fig. 2) long, cylindrical, porrect, extending prominently forward, covered with appressed scales. Antennal club relatively long and slender, not sharply constricted into the long, pointed apiculus. No costal fold in male, but sometimes a patch of scales on the upper surface of the primary.

Vein M_2 of primary intermediate or closer to M_1. R_4 and R_5 of primary closely parallel to each other at their bases, sometimes even short-stalked (fig. 4). Cu_2 of primary usually noticeably closer at its origin to base of cubital stem than to origin of Cu_1.

Fourth joint of mid and hind tarsi about the length of the fifth or slightly shorter (fig. 3). Hind tibiae with two pairs of spurs. Abdomen shorter than the secondaries, which are frequently produced at the anal angle.

The subfamily is confined to the Old World, and is equivalent to Section C of the Pamphilinae of Watson (1893).

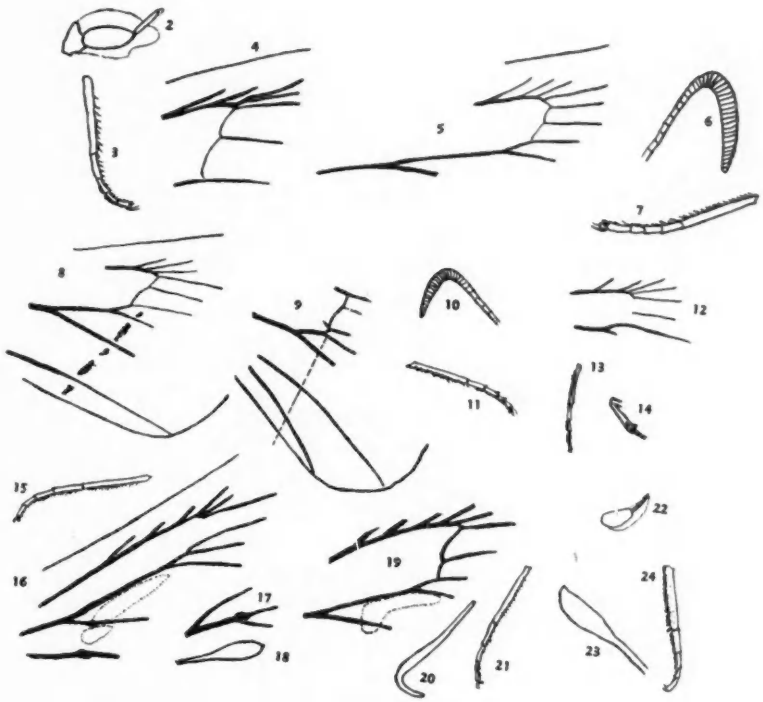
Genera examined: *Coeliades, Pyrrhochalcia.*

Subfamily **Pyrginae**

Vein M_2 of primary intermediate between M_1 and M_3, or slightly closer to M_1 (fig. 5). Mid and fore tibiae never spined; hind tibiae only rarely so. Male frequently with a costal fold, never with a stigma.

Vein Cu_2 of primary usually closer at its origin to the base of the cubital stem than to origin of Cu_1 (fig. 5). Fourth joint of mid and hind tarsi usually about the length of the fifth joint or only slightly longer or shorter. Hind tibiae occasionally lacking medial pair of spurs.

This is a subfamily which traditionally has been divided into at least two large groups. The groups recognized by Evans, Lindsey, and Godman and Salvin for the regions under their respective considerations may work fairly well for those regions, but are based on such vari-



FIGS. 2-24. Structural details of the Hesperiidae. 2. *Coeliades forestan*, palpus (limit of vestiture indicated). 3. The same, tarsus of mesothoracic leg. 4. The same, portion of venation of primary, showing short-stalking of R_4 and R_5. 5. *Pyrgus syrichtus*, portion of venation of primary, showing entire length of cubitus with origins of Cu_1 and Cu_2. 6. *Pyrrhopyge pseudohadassa*, end of antenna. 7. The same, tarsus of middle leg. 8. *Hesperilla donnysa* ♂, portion of venation of primary, showing typical position of stigma in the Trapezitinae and position of M_2 closer to M_1. 9. The same, portion of venation of secondary, showing end of cell (note that angle of discocellular extended by dashed line intersects anal margin). 10. The same, end of antenna. 11. The same, tarsus of mesothoracic leg. 12. *Carterocephalus palaemon*, portion of venation of primary. 13. The same, tarsus of mesothoracic leg. 14. The same, tibia of prothoracic leg (note very short epiphysis and spines distal to it). 15. *Hesperia ottoe* ♂, tarsus of mesothoracic leg. 16. The same, portion of venation of primary, showing typical stigma and swellings of Cu_2 and A, origin of branches of radius, and curving of M_2 toward M_3. 17. The same, portion of venation of secondary, showing bulge on radius. 18. The same, outline of antennal club. 19. *Hypoleucis ophiusa* ♂, portion of venation of primary, showing contrasting trends of Calpodidi with fig. 16. 20. The same, outline of antennal club. 21. The same, tarsus of mesothoracic leg. 22. *Taractrocera anisomorpha*, second and third joints of palpus (limit of vestiture indicated). 23. *Megathymus neumoegeni*, outline of antennal club. 24. The same, tarsus of mesothoracic leg. All these figures have been drawn directly from images projected from microscope slides, and are to the same scale.

able characters and are so impossible of application to specimens from other territories, that their validity as anything but artificial separations for convenience may be questioned. There is complete intergradation, for example, in any character of the antennal club; the length of the cell of the primary, when carefully measured, will be found only seldom to exceed two-thirds of the costa and to intergrade down to slightly over half the length of the costa. The relative position of M_2 of the secondary, as well as any other feature of neuration, proves to be an inconsistent criterion. Therefore, I am unwilling to attempt further division of the subfamily.

The subfamily is largely equivalent to the Hesperiinae of the older authors (*e. g.*, Watson and Godman & Salvin). It is well-represented in both the Old and New Worlds.

Genera examined: *Acolastus, Bungalotis, Celaenorrhinus, Cogia, Eantis, Epargyreus, Erynnis, Eudamidas, Eudamus, Grynopsis, Heliopetes, Netrocoryne, Pholisora, Pyrgus, Sarangesa, Xenophanes.*

Subfamily **Pyrrhopyginae**

Antennal club thick, blunt, with terminal three-fifths or more recurved (fig. 6). Fourth tarsal joint of *all* legs shorter than fifth; third tarsal joint of mid (and sometimes hind) tarsus usually at least slightly shorter than fifth joint (fig. 7).

Cell of primary about two-thirds length of costa, or longer. No stigma nor costal fold. Two pairs of tibial spurs on the metathoracic legs of most genera (not, for example, in *Mahotis*). M_2 of primary almost intermediate or slightly closer to M_3.

The Pyrrhopyginae are confined to South and Central America except for an occasional stray into the southwestern United States.

Genera examined: *Jemadia, Mahotis, Mysoria, Myscelus, Oxynetra, Pyrrhopyge.*

Subfamily **Megathyminae**

A clearly distinguished group of large, heavy-bodied, strong-winged skippers. The larvae bore in the stems of plants, principally Yucca.

One pair of terminal spurs on mid and hind tibiae, which are also spined. Epiphysis on prothoracic tibiae small. Fourth tarsal joint about the length of the fifth (fig. 24). Vein M_2 of primary directed toward M_1. Antennal club stout, practically blunt, without apiculus or prominent point (fig. 23).

The subfamily is strictly North American. It has frequently been accorded full family rank under the Hesperioidea.

Genus examined: *Megathymus.*

Subfamily **Trapezitinae**

Fourth tarsal joint of mid and hind legs about length of fifth, or frequently conspicuously shorter (fig. 11). M_2 of primary slightly closer to M_1, or intermediate most of length (fig. 8); may be closer to M_3 at very base only. On the secondaries, M_2 is present, at least weakly, and is never curved toward M_3; there is evidence of a branch

from the medial stem within the cell at the base of M_3; angle of the discocellular if extended intersects anal margin of wing rather than anal angle or outer margin (fig. 9). Third joint of palpus short, never long and awl-like. Epiphysis well developed.

Members of the subfamily are found only in the regions of Australia and New Guinea. The group is equivalent to lead a of Watson's key (1893, p. 71) to the Pamphilinae.

Tribe **Trapezitidi**

Antennae with an apiculus, but no bend in the proximal half of the club. No stigma in the male. Hind tibiae with two pairs of spurs.

Genus examined: ***Trapezites.***

Tribe **Hesperillidi**

Antennal club thick, bent in the proximal half, frequently blunt. Terminal three-fifths or more of club often recurved as in the Pyrrhopyginae (fig. 10). Two groups:

A. Male with a stigma (narrow, oval, or broad) entirely on outer half or two-thirds of primary. Two pairs of spurs on hind tibiae.

Genera examined: ***Dispar, Hesperilla, Signeta, Toxidia.***

B. Male without stigma. One pair of spurs on hind tibiae.

Genus examined: ***Mesodina.***

Subfamily **Hesperiinae**

Members of this large subfamily may be quickly identified by the fact that vein M_2 of the primary is nearly always strongly curved toward M_3, a character shared only with the Megathyminae (fig. 16, 19). In the tribe Heteropteridi, the vein is straight (fig. 12), but the spining of the mesothoracic tibiae will separate the insects from the Pyrginae, and the reduced epiphysis (fig. 14) and absence of a stigma will avoid confusion with the Trapezitinae. (Also, none of the Heteropteridi occur in Australia and New Guinea, the sole range of the Trapezitinae.) Males often with a discal stigma on primary, never with a costal fold.

The subfamily is equivalent to the Pamphilinae of some of the older authors, except as they included such groups as the Trapezitinae and the Coeliadinae which are now separated. There is a wide representation of species in the faunas of the globe.

Tribe **Heteropteridi**

Vein M_2 of primary straight and about intermediate between M_1 and M_3 (fig. 12). Fifth tarsal joint on mid and hind legs longer than fourth, or about the same length (fig. 13). Mesothoracic tibiae nearly always spined; metathoracic tibiae sometimes lacking the medial pair of spurs. Epiphysis very small (sometimes absent?) (fig. 14). No stigma in male. Antennal club blunt or acuminate, but without definitely constricted apiculus.

The tribe is of wide distribution, occurring on all continents except Australia, and is equivalent to the Heteropterus Group of Evans (1949),

Group A of the Hesperiinae of Lindsey (1931), and Group I of the Pamphilinae of Godman and Salvin (1900).

Genera examined: ***Butleria***, ***Carterocephalus***. (***Heteropterus***, although not available for examination, would belong here, as would ***Metisella***.)

Tribe **Taractroceridi**

This tribe is defined by the combination of the shape of the third palpal joint and the position of Cu_2 of the primaries. There are two sub-groups and although now, at least, they occur in two widely separated regions of the world they have quite uniform structure, and the tribe is distinguished without difficulty from the other Hesperiinae. Its arc of distribution from Asia and Australia through South America to North America parallels that of a number of plant groups, but as members of this tribe, so far as known, evidently feed on a variety of grasses, no correlation with food plants can be made at present. There is some reason, however, for not considering the two sub-groups as examples of convergence (so common in butterflies).

Third joint of palpus long, awl-like, usually as long as or longer than the width of the second joint (fig. 22). Length of cubitus of primary between origins of Cu_1 and Cu_2 half or less than half the length between origin of Cu_2 and base of cubital stem. M_2 of primary directed towards M_3; M_2 of secondary lacking.

A. Asian and Australian species. Stigma often present in male. Short apiculus present (except in Taractrocera).

Genera examined: ***Ocybadistes***, ***Suniana***, ***Taractrocera***. (***Potanthus*** (=***Padraona***), although not examined, undoubtedly belongs here also).

B. American species. Stigma absent in male, except for ***Copaeodes***, which has a peculiar narrow longitudinal mark. Apiculus absent; club blunt.

Genera examined: ***Ancyloxypha***, ***Copaeodes***, ***Oarisma***.

The tribe is not equivalent to any other group previously proposed (in part because of the omission of ***Thymelicus*** (=***Adopaea***) from the tribe), but it includes portions of the following: Group B of the Hesperiinae of Lindsey (1931), Group II of the Pamphilinae of Godman and Salvin (1900), and the first few genera of the Taractrocera Group of Evans (1949).

Tribe **Hesperiidi**

The two large tribes Hesperiidi and Calpodidi are difficult to separate on any one criterion, but there is an abundance of trends which ***usually*** hold, and which in combination will readily place almost any member of the Hesperiinae which does not fit into one or the other of the two preceding distinctive tribes. There are at least a few exceptions to any one of the following characters, but any insect in the Hesperiidi will possess more of them than one in the Calpodidi. A few smaller groups in the tribe might be of use, but their characterization is beyond the scope of this consideration.

Apiculus very short and sharply constricted from rest of antennal club, or absent (fig. 18); usually composed of fewer segments than the rest of the rather stout club. Tibiae nearly always spined, although

weakly so on the fore tibiae. Fourth tarsal joint on mid and hind legs as long as or longer than the fifth (fig. 15) (shorter in Australian genera *Cephrenes* and *Telicota*).

Stigma frequently present in male, causing in most cases a peculiar swelling on veins Cu_2 and A (fig. 16); in these males there is also a bulge on the radius of the secondary, just before the origin of M_1 (fig. 17). Vein M_2 of primary often very much curved toward M_3 (fig. 16). Origin of Cu_2 of primary about half-way between base of cubital stem and origin of Cu_1 or closer to the latter (unless displaced by stigma in male). Origins of R_4 and R_5 often contiguous (fig. 16). Third joint of palpus usually short, but occasionally long and awl-like (as in *Amblyscirtes* and *Thymelicus*).

An orange or tawny is the predominant color in this tribe (with several exceptions, as in *Amblyscirtes* and *Oligoria*). The tribe is very extensively developed in the holarctic region. Included in the tribe are Group C of the Hesperiinae of Lindsey (1931), Groups III, IV, and VI of the Pamphilinae of Godman and Salvin (1900), and the Hesperia Group and in part the Taractrocera Group of Evans (1949).

Genera examined: *Amblyscirtes*, *Cephrenes*, *Hesperia*, *Hylephila*, *Ochlodes*, *Oligoria*, *Poanes*, *Polites*, *Telicota*, *Thymelicus*.

Tribe **Calpodidi**

As in the previous tribe, smaller groups would be of use as an artificial expedient in arranging the genera of a certain fauna, but the limited extent of the present study has been enough to indicate clearly that the presence of forms intermediate between the groups that have been recognized by different authors suggests no more than one tribe for these genera. The following characters, as in the Hesperiini, are individually open to exception, but as in that group they will in combination clearly characterize the tribe.

Antennal club tapering into apiculus, not sharply constricted; apiculus relatively long (fig. 20), composed of about as many segments as the rest of the club. Tibiae without spines, or spines relatively few. Fourth tarsal joint on mid and hind legs as long as, or shorter than, fifth joint (fig. 21) (longer, however, in *Calpodes*).

Stigma frequently present in male, but no swellings on veins as in the Hesperiidi. M_2 of secondaries may be conspicuous or (more frequently) completely absent. Origin of Cu_2 of primary frequently closer to base of cubital stem than to origin of Cu_1. R_4 and R_5 usually quite separate at their origins. Third joint of palpus short.

With numerous exceptions, brown is the predominant color in this large tribe, which is not at all well developed in the holarctic region. The tribe includes Group D of the Hesperiinae of Lindsey (1931), the Gegenes Group of Evans (1949), the Acleros, Ceratrichia, Ploetzia, and Gegenes Groups of Evans (1937), and groups VII and VIII of the Pamphilinae of Godman and Salvin (1900) (except for the latter's use of the names *Coeliades*, due to incorrect type-fixation, and *Padraona*, which = *Potanthus*, a genus in the Taractroceridi restricted to Asia and Australia).

Genera examined: *Baoris*, *Caenides*, *Calpodes*, *Euroto*, *Hypoleucis*, *Leona*, *Pardaleodes*, *Perichares*, *Prenes*, *Pteroteinon*, *Pyrrhopygopsis*.

SOME PHYLOGENETIC TRENDS IN THE FAMILY

A phylogenetic chart showing possible relationships of the subfamilies and tribes of the Hesperiidae is proposed in figure 25. An ancestral stock is assumed, somewhat resembling *Euschemon*, but differing, probably, in having evidence of the medial stem and in having both pairs of spurs developed on the tibiae of the metathoracic legs. The presence of a frenulum and the lack of specialization in antennal club and in neuration clearly indicate the primitive nature of *Euschemon*.

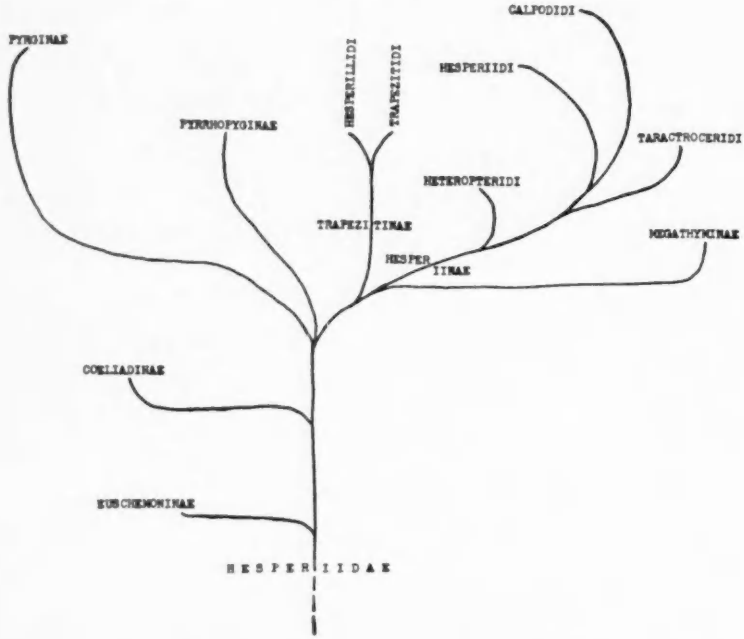


FIG. 25. Suggested phylogeny of the Hesperiidae.

The Coeliadinae also represent a relatively primitive group within the family; except for loss of a frenulum and development of a long third palpal joint, the group shows little advancement over *Euschemon*.

Loss of the medial spurs of the hind tibiae does not appear to be a particularly significant characteristic in classification. Loss is incomplete in the Euschemoninae, and occurs in a few Pyrrhopyginae, all Megathyminae, a small group of the Hesperillidi (Trapezitinae), some Heteropteridi (Hesperiinae), and some Pyrginae. The weight of other distinctions makes presence or absence of these spurs an incidental characteristic (except in the Megathyminae, where it is consistent).

More significant is the neuration, especially the position of vein M_2 of the primaries. To the left of the chart are lines in which there has

been no tendency for this vein to approach M_3: the Pyrginae, a large group of world-wide distribution; the Pyrrhopyginae, a strictly American line of development; and the Trapezitinae. The latter are an essentially Australian group more intimately related to the Hesperiinae than to the other subfamilies; in the Trapezitinae M_2 may be closer to M_3 at the very base only—there is not the gradual curving which is so pronounced in the Megathyminae and almost all of the Hesperiinae. The Heteropteridi evidently are a tribe in which the more primitive straight position of M_2 has been retained, the remainder of the Hesperiinae developing parallel to the Megathyminae in the shifting of this vein.

The secondary male characteristics of a costal fold in the Pyrginae and of a distinct discal stigma in the Hesperiinae and Trapezitinae is a divergence which, while not represented universally in these subfamilies, is at least extremely consistent in being limited to them respectivelv

The Pyrrhopyginae and the Megathyminae are both very well-defined groups, the former with the recurved antennal club and long discal cell, and the latter particularly in regard to the endophytic larval habit. Very likely both have had comparatively long independent histories in the New World.

Several striking illustrations of convergence are found in the family. The antennae of the Hesperillidi and of the Pyrrhopyginae are remarkably similar. Some of the Calpodidi show a strong general resemblance to certain Pyrginae, and *Pyrrhopygopsis*, as the name implies, appears superficially much like *Pyrrhopyge*.

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REVISION OF THE GENUS CALENDRA (FORMERLY SPHENOPHORUS) IN THE UNITED STATES AND MEXICO (COLEOPTERA, CURCULIONIDAE), by PATRICIA VAURIE. Bull. Amer. Mus. Nat. Hist. 98 (2), 1951, pp. 29–186, figs. 1–116, tables 1–8. 1951.

This is a book to warm the heart of many an entomologist. Not devoted to an exotic group that the ordinary student never sees, nor to a domestic group that only the specialist is interested in, Mrs. Vaurie's monograph concerns a large genus of handsome conspicuous weevils well known under the name of billbugs to both economic entomologist and amateur. 71 species and 12 subspecies are described of which 64 species and 11 subspecies occur north of the Mexican border and 21 species and 2 subspecies south of that line. In this large array of taxonomic forms, only two new ones (*championi* from Mexico and *cazieri* from Texas) are recognized, revealing how thorough the work of F. H. Chittenden on the group in the first quarter of the present century really was. Of the 83 forms recognized, no less than 30 were described by Chittenden, but the fact that 24 additional names proposed by Chittenden are regarded as synonyms by Mrs. Vaurie shows how different the taxonomic ideas of these two authors are. At least in terms of Mrs. Vaurie's concepts, the present knowledge of the Nearctic components of the genus must be nearly complete.

The test of a taxonomic work, of course, is how it performs in action. Accordingly, the reviewer assembled the 280 specimens of *Calendra*, mostly unnamed, present in his collection of Coleoptera from the Pacific Northwest, and in a little over three hours was able to sort them in a satisfactory manner into nine of the twelve species cited by Mrs. Vaurie from that area. As additional evidence of the completeness of Mrs. Vaurie's work, scarcely any significantly new Northwestern distribution was revealed by this material. Of two species, however, recorded by Mrs. Vaurie from Idaho and Oregon, the reviewer has Washington specimens: *gentilis* LeC. from Seattle and Smyrna and *graminis* Chitt. from Beverly, Seattle, and Vancouver.

Both Mrs. Vaurie and the American Museum of Natural History are to be congratulated on the appearance of a nice book.—MELVILLE H. HATCH.

NOTES ON BRUCHOMYIA AND NEMOPALPUS

(Diptera, Psychodidae)

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The collection of several species of *Bruchomyia* and *Nemopalpus* by my colleagues and myself during recent work with *Phlebotomus* has stimulated the present note, since the three genera are rather closely related and appear to frequent somewhat similar habitats. During the course of *Phlebotomus* collecting in Mexico, Panama, the West Indies, Peru and Brazil, some eighty or more specimens of these genera, representing seven species, two of *Bruchomyia* and five of *Nemopalpus*, have been gathered together. The purpose of this note is to describe, or redescribe, this material, pointing out in passing certain structures of possible taxonomic significance or phylogenetic interest. The material has mostly been studied after mounting, so that in only a few cases has it been possible to make notes on the color and character of the vestiture. This is unfortunate, as a number of species seem to have been largely based on differences in the vestiture, and it has been impossible in one case to place my material with certainty on the basis of structural characters. At the same time I have taken the opportunity to give a check list of the described species, and to prepare a key to the Neotropical species of *Nemopalpus*.

In describing the genitalia I have used the same terminology applied in a previous paper (Fairchild & Hertig 1947) to the genitalia of *Phlebotomus*. This terminology differs in some respects from that used by Alexander and others in describing these insects. Thus the coxite is often termed the basistyle, while the parameres are usually referred to as gonapophyses. Whether the structures herein called parameres are really homologous with the parameres of *Phlebotomus* is uncertain; their sclerotized blade-like or foliaceous character in *Nemopalpus* is not duplicated in any *Phlebotomus*. It is possible that they are in reality homologous with the basal tuft of the coxite so often developed in *Phlebotomus*. The aedeagus is the median intromittent organ. In *Nemopalpus* and *Bruchomyia* the actual genital orifice appears to be single, while in *Phlebotomus* there is a pair of tubular filaments. In some species of *Phlebotomus*, *e.g. P. perfiliewi* Parr. (Hertig 1949), and probably in all, the genital filaments are inserted deeply into the spermathecal ducts, often, if not always, to the full length of the latter during copulation. This results in a correlation of the length of the spermathecal ducts and genital filaments in the sexes of a given species of *Phlebotomus*. In *Nemopalpus* and *Bruchomyia*, however, the single spermatheca has a very long and slender duct, while the intromittent

[1]Cost of publication is paid by the Gorgas Memorial Institute.

organ of the male is quite short and appears incapable of any great degree of exsertion. All three genera appear to possess some sort of pumping device to inject the sperm. In the species studied here of both *Bruchomyia* and *Nemopalpus*, the vasa deferentia are long well sclerotized ducts with annular thickenings in their walls, much like tracheae. They are better developed in *Nemopalpus*, where they terminate in funnel-like expansions bearing numerous fine spines within. In *Bruchomyia* in cleared and stained material, these ducts are more slender, less sclerotized and without the funnel-shaped terminations. The lateral lobes of the ninth tergite, so prominent a feature of the genitalia of *Phlebotomus*, are wholly absent in the Neotropical species of *Nemopalpus* and *Bruchomyia*. It may be well to note here that the description of the genitalia of *Bruchomyia argentina* given by Cole (1927) is based on the female, not the male as he supposed.

The mouth parts of both *Bruchomyia* and *Nemopalpus* are short and unfitted for blood-sucking. Mandibles are absent as functional elements while the maxillae are membranous structures with a ciliate margin, quite unfitted for cutting. The cibarium is rather broad and lightly sclerotized, without a chitinous arch or teeth of any kind in the species examined. The pharynx is much like that of *Phlebotomus*, but wholly unarmed.

Nemopalpus Macquart

1838, in Webb et Berthelot, Hist. Nat. d'Iles Canaries, Ent., 1, Diptera, p. 102 (with *N. flavus* Macq. sole species). Eaton, 1904, Ent. Month. Mag. Ser. 2, 15: 55. Becker, 1908, Mitt. Zool. Mus. Berlin, 4: 71–72 (recharacterizes genus from fresh material). Tonnoir, 1922, Ann. Soc. Ent. Belgique, 62: 125–136, a plate (describes *N. pilipes* from Argentina). Alexander, 1921, Ins. Ins. Mens., 9: 157–160; 1928, Proc. Linn. Soc. N. S. Wales, 53: 291–294; 1929, Proc. U. S. Nat. Mus., 75(7): 1–9, 2 figs.; 1940, Rev. Ent., 11(3): 793–799. Edwards, 1929, Ann. Mag. Nat. Hist., 10(3): 421–423. Tonnoir, 1940, 6th Congr. Internat. Ent. Madrid, 1935, pp. 203–213, 7 figs.

Nygmatodes Loew 1845, Dipt. Beitr. 1: 9.

Palaeosycorax Meunier, 1905, Misc. Ent., 13: 50 (with *P. tertiariae* Meun., Baltic amber). Edwards, 1921, Ann. Mag. Nat. Hist., (9)7: 437–439 (desc. *P. molophilina* from Baltic amber).

The genus now includes 19 species, a check list of which is given below. As can be seen the group is world-wide in distribution within the tropics, only the fossil species being extra-tropical. Although generally considered very rare insects, they will probably be found to be fairly abundant when searched for carefully in suitable habitats. The adults seem to prefer dark and humid places, such as hollow trees, the crevices between the buttressed roots of large trees, rock crevices, etc., as daytime resting places and they are often taken in association with *Phlebotomus*. They are also taken occasionally attracted to lights. Nothing appears to be known of the early stages. The eggs contained within the bodies of captured females are relatively large, as large or larger than those of *Phlebotomus* in proportion to the size of the insect. They appear to be similar to *Phlebotomus* eggs, smooth, long oval and fairly thick shelled.

Nemopalpus is far more diversified structurally than *Bruchomyia* and to a considerable extent structural characters appear to reflect geographical distribution. Thus all the Old World species, including

the fossil ones, have R_2 longer or equal to R_{2+3}, while the New World species, with two exceptions, have R_{2+3} very much longer than R_2. Most of the Old World species have r-m proximal to the fork of M_1–M_2, whereas the New World species are divisible into two groups in respect to this character. The Old World species of which the male genitalia have been adequately described, show little of the great complexity and bizarre apendages of many of the New World species; in particular the parameres seem lacking or rudimentary. The ascoids are not usually mentioned in descriptions, only those of *N. zelandiae* being described for Old World species. In this case they are forked or antler-like structures, resembling the ascoids in some species of *Psychoda*. In the New World species of both *Bruchomyia* and *Nemopalpus*, where these structures have been noted, they are circular or oval peltate discoidal sacs, one or rarely a pair per segment in *Nemopalpus*, one or two pairs in *Bruchomyia*.

It seems very probable that this diversity of structure will eventually lead to the recognition of one or more named segregates, but until adequate material of both sexes of the genotype, *N. flavus* Macq., can be studied, it would be premature to do so. Becker's (1908) description of the male genitalia of *flavus*, apparently drawn from a pinned specimen, is not very enlightening but suggests a structure rather different from that of any of the Neotropical species. The genitalia of the other Old World species which have been at all adequately described differ widely among themselves and from the Neotropical species.

CHECK LIST OF SPECIES OF NEMOPALPUS

OLD WORLD SPECIES

australiensis Alexander 1928, Proc. Linn. Soc. N. S. Wales, 53: 293–294, fig. 1 (wing) (♀; New South Wales, Australia).

capensis Edwards 1929, Ann. Mag. Nat. Hist., (10) 3: 422, text fig. (♂; Port St. John, Pondoland, South Africa).

flavus Macquart 1838, in Webb et Berthelot, Hist. Nat. d'Iles Canaries, Ent., 1, Diptera, p. 102 (♂; Canary Islands).

orientalis Edwards 1928, Journ. Fed. Malay States Mus., 14: 65 (♀; Cameron's Highlands, Gunong Berumban, Malaya).

unicolor Edwards 1933, Journ. Fed. Malay States Mus., 17: 257 (♀; Lumu Lumu, slopes of Mt. Kinabalu, Br. N. Borneo).

zelandiae Alexander 1921, Ins. Ins. Mens., 9: 158, 1 fig. (no sex, New Zealans); Tonnoir, 1940, 6th Congr. Internat. Ent. Madrid, 1935, pp. 203–213, figs. (♂, ♀; various localities on both islands).

NEW WORLD SPECIES

antillarum n. sp. (described in this paper from Hispaniola).

arroyoi de Leon 1950, Univ. San Carlos, Guatemala, pub. no. 150, pp. 14–16, figs. 12–18 (♂, ♀; Mazatenango, Guatemala).

brevinervis Barretto and d'Andretta 1946, Livro homenagem a R. F. d'Almeida, no. 6, pp. 60–62, figs. 1–6 (♂; S. Paulo, Brasil).

dampfianus Alexander 1940, Rev. Ent. 11: 796–798, figs. 2, 4 (♂; Chiapas, Mexico).

dissimilis Barretto and d'Andretta 1946, Livro homenagem a. R. F. d'Almeida, no. 6, pp. 62–63, figs. 7–8 (♀; Espirito Santo, Brasil); Barretto 1950, Pap. Avulsos Dept. Zool., Sec. Agric., S. Paulo, 9 (22): 341–343, figs. 1–4 (♂; S. Paulo, Brasil).

immaculatus Freeman 1949, Ent. Month. Mag., 85: 86–87, figs. 1–3 (♂; Sta. Catharina, Brasil).

mopani de Leon 1950, Univ. San Carlos, Guatemala, pub. no. 150, pp. 9–14, figs. 2, 5–11, 21 (♂, ♀; Peten, Guatemala).

moralesi de Leon 1950, Univ. San Carlos, Guatemala, pub. no. 150, pp. 17–19, figs. 19–20 (♂, ♀; Mazatenango, Guatemala).
pallipes Shannon and Del Ponte 1927, Rev. Inst. Bact. Dept. Nac. Higiene, Buenos Aires, 4 (7): 733–744 (♀; Iguazu Falls, Argentina, as *Bruchomyia*).
pilipes Tonnoir 1922, Ann Soc. Ent. Belgique, 63: 130–134, figs. 1–8 (♂, ♀; San Bernardino, Paraguay).
maculipennis Barretto and d'Andretta 1946, Livro homenagem a R. F. d'Almeida, no. 6, pp. 64–66, fig. 9 (♀; S. Paulo, Brasil).
vexans Alexander 1940, Rev. Ent. 11: 798, fig. 5 (♂; Rio de Janeiro, Brazil).
sziladyi Tonnoir 1940, 6th Congr. Internat. Ent. Madrid, 1935, pp. 203–213, 7 figs. (♂; Suiza de Turrialba, Costa Rica).

FOSSIL SPECIES

molophilinus Edwards 1921, Ann. Mag. Nat. Hist., Ser. (9) 7: 437–439, text fig. (♂, ♀; Baltic Amber, East Prussia) described as *Palaeosycorax*.
tertiariae Meunier 1905, Miscell. Ent. 13: 50 (♂; Baltic Amber) described as *Palaeosycorax*.

I have been able to recognize from the descriptions all but two of the species of *Nemopalpus* described from the New World, and to place them in the key. *N. pallipes* Shannon and del Ponte was described as a *Bruchomyia* and compared with *B. argentina* Alex. Only females were available to Shannon and del Ponte, and the description is largely one of the color and vestiture. No figure is given nor is the number and disposition of the types mentioned. Alexander later (1929) says the species is very close to *pilipes* Tonn., differing only in color, being darker and with paler legs. He states that the Type is in the United States National Museum. Alexander also identifies a male specimen of *pilipes* Tonn. from Iguazu Falls, the type locality of *pallipes*. It is possible that *pallipes* is another synonym of *pilipes*, a species which Shannon and del Ponte did not know.

Of *Nemopalpus moralesi* de Leon I have seen only the female, which is not separable from females of *N. arroyoi* de L. The original description of the male is not entirely adequate, and the figures accompanying the description are not very clear. The species seems to have a style somewhat like that of *N. arroyoi*, but with four cylindrical finger-like lobes. The parameres appear to be triramous, two branches hooked upwards, the third downwards. The aedeagus would appear to be similar to that of *arroyoi*. The wing is like *arroyoi*, *sziladyi* and *mopani*, with short R_2. The presence of erectile hairs on the abdomen is not noted, but neither were they noted in the description of *mopani*, although the modifications of the lateral margins of the tergites bearing these tufts were noted and can be seen in one of the photomicrographs. The similarity of the structure of the style of *moralesi* to that of *arroyoi* makes it seem likely that erectile tufts were absent in the former also.

KEY TO MALES

1. Cross vein r-m quite far distal to fork of M_1–M_2: R_2 much shorter than stem R_{2+3}; a small setulose lobe on inner apex of coxite; no erectile abdominal hair tufts 2
Cross vein r-m close to or quite far proximal to fork of M_1–M_2: no lobe on coxite; erectile abdominal hair tufts present or absent 3
2. Style with several setose arms; parameres blade-like or foliaceous . . . . . **pilipes**
Style simple, feebly lobed; parameres probably absent, not mentioned in description . . . . . **dampfianus**

3. R_2 considerably longer than stem vein R_{2+3}; r-m cross vein at level of or somewhat distal to fork of M_1–M_2 4
   R_2 very much shorter than stem vein R_{2+3}; r-m cross vein considerably proximal to fork of M_1–M_2 5
4. Style simple, broadly hooked; parameres virtually absent; tufts of erectile hairs on abdomen on last two segments only, lying transversely in the modified 6th and 7th tergites ..... **immaculatus**
   Style complex, with three curved teeth and numerous setae; parameres blade-like; no abdominal tufts mentioned ..... **brevinervis**
5. No tufts of erectile hairs on abdomen; style with two finger-like setose lobes and a flat rounded blade ..... **arroyoi**
   Tufts of erectile hairs present on sides of tergites 3 to 7, folding forward into a median dorsal groove 6
6. Style simple, without lobes or blade-like extensions; parameres slender blades bearing apical spinelets ..... **dissimilis**
   Style with two or more long blade-like extensions; parameres otherwise 7
7. Style with two simple broad, blade-like extensions; parameres very long, recurved, deeply bifid ..... **antillarum**
   Style with one long, slender, twisted extension and a second forked blade-like extension; parameres otherwise 8
8. Forked extension of style long and slender, as long as simple extension, deeply forked; parameres broad, simple, not deeply divided; tip of aedeagus relatively simple ..... **mopani**
   Forked extension of style short and broad, the fork shallow; parameres deeply bifid; Tip of aedeagus flared outwards into lateral wing-like extensions ..... **sziladyi**

Nemopalpus mopani de Leon

Figs. 14, 15, 32–35

1950, Univ. San Carlos, Guatemala, pub. no. 150, pp. 9–14, figs. 2, 21, 5–11. (♂, ♀: Mopan and Poptun, Peten, Guatemala, in shallow limestone caves.)

Through the kindness of Dr. de Leon I have been able to study a series of this species and to make the accompanying drawings. The species appears to be closest to *N. sziladyi* Tonn. from Costa Rica, from which it differs in the much longer branches of the double spine on the style and in much lesser development of the spinulose tip of the aedeagus. The parameres also are simpler, Tonnoir's species having these structures deeply bifid.

Male.—Wing length 3.51 to 4.05 mm. Head with vertex rather prominent, the eye very large and separated by a narrow space above the antennae. Proboscis short, not as long as first three palpal segments. Labella large and fleshy, mandibles not discernible, maxillae present but short. Cibarium nearly as broad as long, no chitinous arch and no teeth or spines present. Pharynx long and slender, well sclerotized, unarmed. Third palpal segment with a dense patch of Newstead's scales at about the middle. Ascoids small, platter shaped or perhaps bladder shaped in life, single, inserted on the distal third of each segment, including the terminal one. Antennae of two basal and 14 cylindrical flagellar segments, the terminal segment not abruptly shortened nor markedly different from the preceding ones.

Dorsum of thorax heavily pigmented, the pleura and coxae much less so. A patch of small setae present on the upper part of the mesanepisternum, a patch of larger setae on the upper part of the mesepimeron and scattered small setae on the upper half of the sternopleuron. Femora clothed with ligulate scales and a few erect setae of which a few

on the mid femora are quite heavy. Tibiae and tarsi with flat scales and scattered heavy spines. Wings with veins clothed with long hairs, longest on the costa and posterior margin. Venation as figured, quite constant in all material seen.

Abdomen clothed with long semi-erect setae. Sides of third to seventh tergites inclusive bearing rounded sclerotized bosses thickly beset with long erect setae. These setae are longer than the other abdominal setae and probably fold forward into the grooves of the first and second tergites. Second sternite hardly differing from the third. First and second, but not third, tergites split or grooved dorsally.

Genitalia as figured. The parameres are heavily sclerotized blade-like structures. The wrinkled sclerotized ducts leading from the genital pump extend forward to about the fourth abdominal segment, where they terminate in large funnel shaped expansions. They are presumably the vasa deferentia. The genital pump appears to be similar to that of *Phlebotomus*, but the aedeagus is single, membranous and spinulose, with a single forked spinulose internal structure which seems to correspond to the genital filaments of *Phlebotomus*, though whether it is tubular cannot be determined. The ninth tergite is well developed, clothed with long heavy setae, but without lobes or protuberances, bearing at its apex the well developed cerci and a median triangular setulose pygidium.

The *female*, of which only one rather poorly preserved specimen is available, does not differ from the male in external characters except that alpha and delta of the wing venation are a trifle longer. The female lacks the lateral tufts on the abdomen. The spermatheca is a single large oval structure indistinguishable from that of *N. arroyoi*. It can be distinguished from the latter species by having a much paler pleura, by the shape of some of the internal sclerotizations of the terminal segments of the abdomen, and by the less developed external lobe on the sides of the ninth tergite.

Material examined: 4♂, 1 ♀ Canchacan, Peten, Guatemala, 19 July 1946, R. de Leon, coll.; 1♂ Palenque, Chiapas, Mexico, 28 March 1951, at light. Fairchild and Hartmann coll.

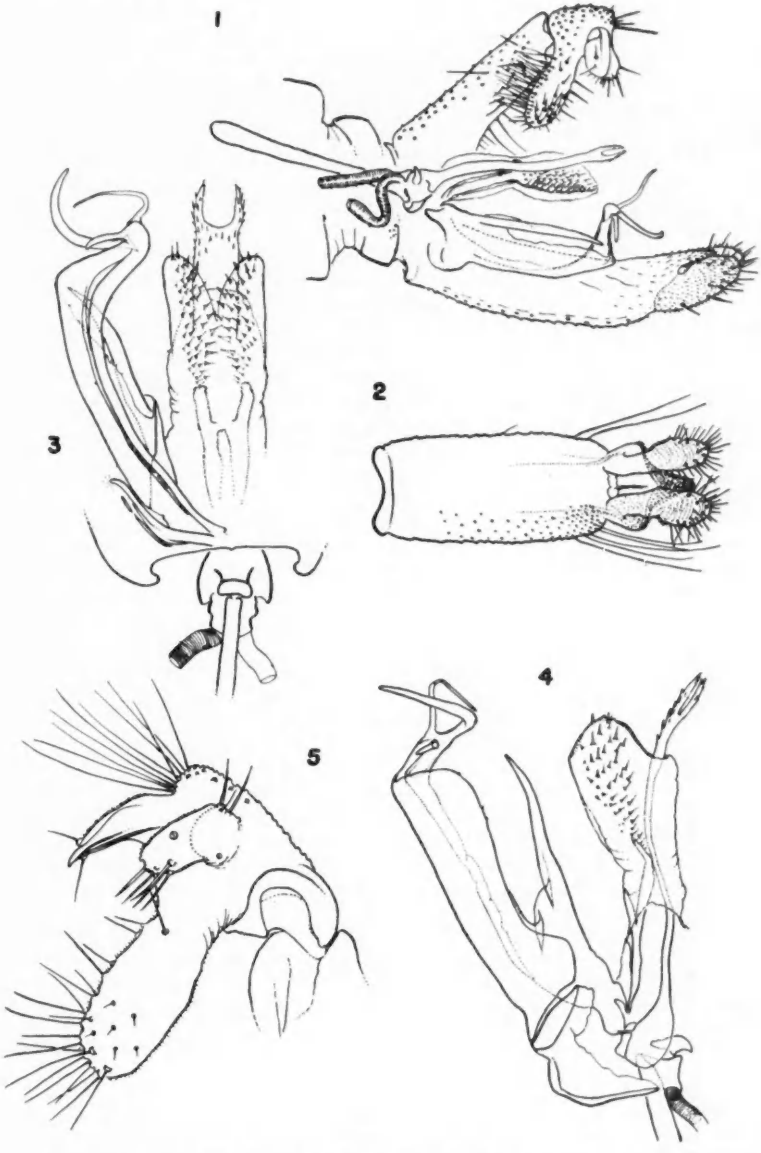
Nemopalpus arroyoi de Leon

Figs. 1–11, 29, 30, 38

1950, Univ. San Carlos, Guatemala, pub. no. 150, pp. 14–16, figs. 12–15, 15 bis 16–18. (♂, ♀: Mazatenango, Guatemala, in holes in trees.)

In addition to material very kindly sent me by Dr. de Leon, I have a considerable series from several localities at higher elevations in Chiriqui Province, Panama.

Male.—Wing length: 3.87 mm. (Guatemalan specimen); 4.59 to 4.86 (Panama specimens). Venation as figured. Head with vertex prominent, eyes very large and separated by only a narrow space above antennae. Proboscis short, not as long as first three palpal segments, labella large and fleshy, mandibles not discernible, maxillae apparently with membranous tips. Cibarium broad, well sclerotized, without chitinous arch or armature. Pharynx long and slender, pigmented, well sclerotized, unarmed. Third palpal segment with a dense patch of



Nemopalpus arroyoi de Leon. Male terminalia. FIG. 1, lateral aspect, left coxite, style and paramere removed, × 67; FIG. 2, ninth tergite and cerci, ventral aspect, × 67; FIGS. 3 and 4, aedeagus and paramere, ventral and lateral aspects, × 135; FIG. 5, style, ventral aspect, × 200.

Newstead's scales on the middle third. Ascoids as figured, inserted near apex of each flagellar segment including the last, which is not markedly different from preceding segments.

Whole thorax including coxae heavily pigmented. Small setae present on upper part of mesanepisternum and sternopleuron, larger setae on upper part of mesepimeron. Legs less deeply pigmented, clothed with scales and scattered spines as in *N. **mopani***. Wings clothed with long hairs on the veins, longer on costa and hind margin, the venation quite constant in all material seen.

Abdomen heavily pigmented, clothed with long semi-erect setae. Sides of tergites without sclerotized bosses or tufts of long setae. Second sternite shorter than third, but little modified.

Genitalia as figured, the aedeagus of similar type to that of *N. **mopani***, though the style and parameres are quite different.

Female.—Wing length: 3.87 to 4.32 mm. (Guatemalan specimens); 4.77 to 5.18 mm. (Panama specimens). Venation as in the male. Ascoids as in male but larger, generally, at least on all but the last few segments, a second smaller though similarly shaped ascoid is discernible. Newstead's scales as in male. Thorax, legs and abdomen as in male. Terminal segments of abdomen as figured, the spermatheca as figured.

The internal structures of the female genitalia are quite complicated. Efforts to portray them in a satisfactory manner have been unsuccessful. The spermathecal duct arises ventrally from the oval sclerotized ring shown as the most dorsal element in fig. 7, the two spinulose arms apparently lying on each side of the vagina. Fig. 9 shows in outline what may be some sort of gland. It is very heavily sclerotized, has what appears to be a duct leading forward and dorsally from its posterior end, while the anterior end is deeply sulcate dorsally and bears some sort of sponge-like median appendage. This "gland" is the most ventral of the genital structures. Between it and the opening of the spermathecal duct lie several folded foliaceous sclerotized sheets, one of which bears a median, rugose, funnel-like aperture, opening between the bases of the spinulose arms. The heavily sclerotized lateral structures, the most ventral elements encircling the others in fig. 7 appear to be homologous with the genital fork of *Phlebotomus;* the latter structure perhaps resulting from a fusion of all three of the elements shown in fig. 7. The various foliaceous ventral structures lying above the ventral "gland" are perhaps modifications of the sclerotized structures called the gonapophyses of the eighth sternite in *Phlebotomus* by Sinton (1925). The heavily sclerotized "gland" seems to have no counterpart in *Phlebotomus*, though some

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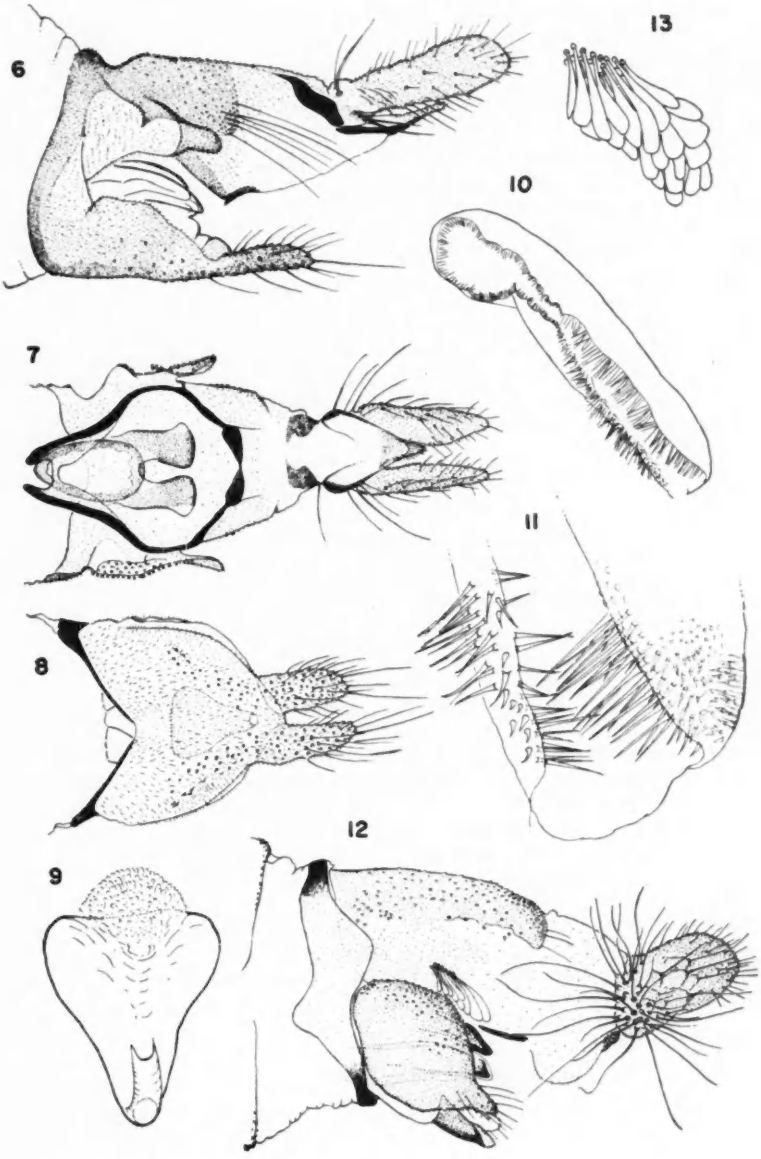
EXPLANATION OF PLATE II

Nemopalpus arroyoi de Leon. Female terminalia. FIG. 6, lateral aspect, × 67; FIG. 7, ninth tergite and associated structures, ventral aspect, × 67; FIG. 8, eighth sternite, ventral aspect, × 67; FIG. 9, sclerotized "gland" lying in eighth sternite, × 200; FIG. 10, spermatheca, × 49; FIG. 11, posterior end of spermatheca, × 200.

Nemopalpus dampfianus Alexander. Female terminalia. FIG. 12, lateral aspect, × 67; FIG. 13, tuft of modified setae from side of ninth tergite, × 200.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other Psychodids have a somewhat similar structure. The spermatheca is a very thin-walled sac-like structure of large size, equalling at least two abdominal segments in length. It appears to have a long slit in one side and is densely spinose within, the spines longer in the posterior end and along the margins of the slit. The duct is very slender and feebly sclerotized, only occasionally visible in its entirety and apparently arising from the posterior end of the spermatheca. The slit in the spermatheca is probably not open to the body cavity but covered by a thin and tenuous membrane, vestiges of which can be discerned in heavily stained specimens.

Materal examined: 1 ♂ 2 ♀, Mazatenango, Guatemala, July, 1945, in hollow Ceiba tree; J. R. de Leon leg.; topotypes. 1 ♂ 2 ♀, Paso Ancho, Chiriqui Prov., Panama, 27 May, 1946, 5000 ft. elev., in hollow tree, P. Galindo coll.; 2 ♂ 1 ♀, El Hato, Chiriqui Prov., Panama, 7 May, 1950, 4500 ft., in buttressed roots, P. Galindo coll.; 2 ♀, same locality, 13 May, 1951, M. Hertig coll.; 9 ♂ 4 ♀, Palo Santo, Chiriqui Prov., Panama, 4600 ft. elev., in buttresses, 18, 24 May, 1950, and 14, 15 June, 1951; 9 ♂ 8 ♀, Bambito, Chiriqui, Panama, 13 June, 1951, in buttresses and rock crevices.

Nemopalpus sziladyi Tonnoir

Figs. 26–28

1940, 6th Congr. Internat. Ent., Madrid, 1935, 1: 203–213, 7 figs. (♂; Suiza de Turrialba, Costa Rica. Types in Mus. Hungarici). Barretto, 1946, Livro homenagem a R. F. d'Almeida, no. 6, p. 59 (in key only). Freeman, 1949, Ent. Month. Mag., 85: 85 (in key only).

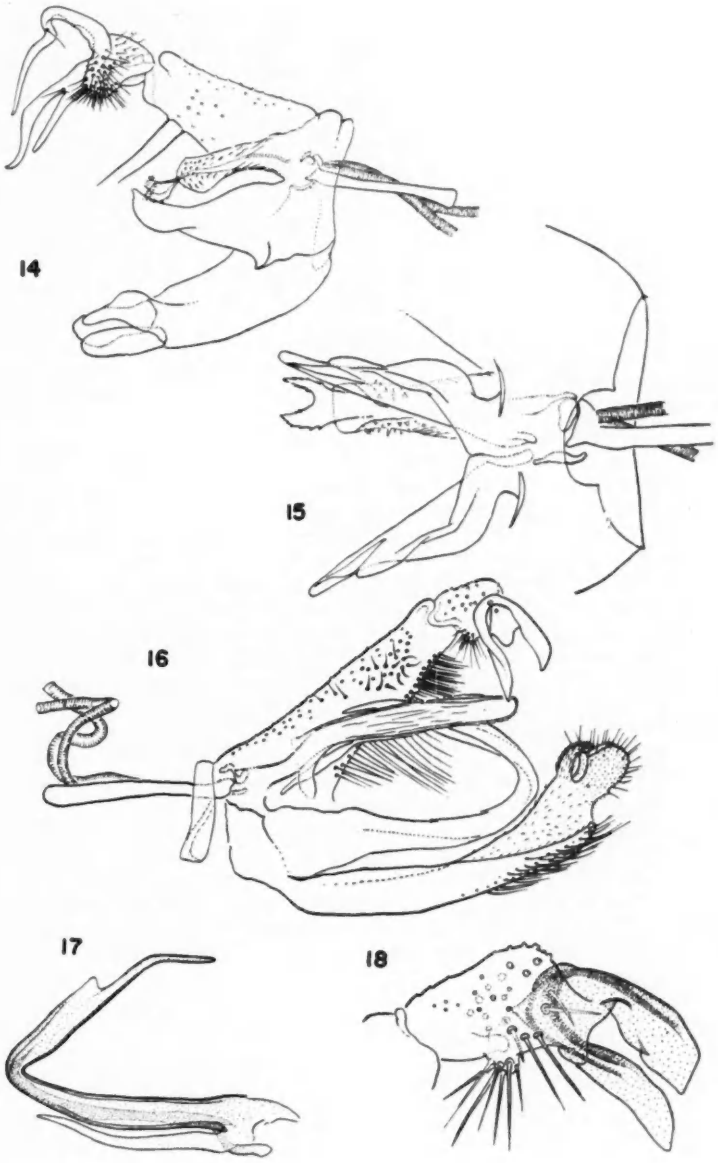
A small series of 2 ♂ and 3 ♀ from Bocas del Toro Province, Panama, less than 100 miles from the type locality, enables me to add a few points to Tonnoir's description and to describe the female.

Male.—Wing length 3.60 mm. Mesonotum dark grey, obscurely striped. Pleura and abdomen beneath clothed with pale silvery grey setae. Long erectile setae of abdomen silvery grey, about the same color as the other abdominal hairs, lying forward as in ***antillarum***, but not as long as in that species. Wings uniformly colored, clothed with dark grey shining setae, those on basal costal area not erect or especially long. Legs clothed with dark grey, shining appressed scales and scattered dark erect setae, not more numerous on the fore legs. The hind tarsi are white scaled, the other tarsi somewhat paler than their respective tibiae. The general impression is of a very large and dark *Phlebotomus* with conspicuously white hind tarsi. The genitalia have been well if somewhat diagrammatically figured by Tonnoir.

EXPLANATION OF PLATE III

Nemopalpus mopani de Leon. Male terminalia. FIG. 14, lateral aspect, right coxite and style removed, × 67; FIG. 15, aedeagus and parameres, ventral view, × 139.

Nemopalpus antillarum n. sp. Male terminalia. FIG. 16, lateral aspect, left coxite, style and paramere removed, × 67, Holotype; FIG. 17, right paramere, lateral aspect, × 67; FIG. 18, style, outer aspect, × 200.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Female.—Wing length, 3.51 to 3.78 mm. Similar to the male in color characters, but lacking the erectile tufts of hairs on the abdomen. Terminal abdominal segments similar to those of *N. arroyoi*, differing in the shape of some of the internal sclerotizations, in the lesser development of the sclerotized ventral "gland" and in the shorter lateral lobes of the ninth tergite. From *N. mopani* the females cannot be differentiated on the basis of available material. In mounted material both *mopani* and *sziladyi* in both sexes show the pleura considerably less infuscated than the notum, while in *arroyoi* the pleura are very deeply infuscated.

Nemopalpus antillarum sp. nov.

Figs. 16–20, 31, 37

Male.—Wing length 3.78 mm. General color dark grey. Mesonotum obscurely striped, clothed with dense and long pale grey hairs. Legs pale grey, thinly clothed with flat appressed scales, the fore tibiae and to a less extent the fore tarsi with numerous long erect hairs on the outer surfaces. Wings very hairy, the hairs pale grey. Posterior fringe of very long hairs in the anal area, becoming progressively shorter towards the apex. Abdomen with dense tufts of very long pale yellowish erectile hairs on lateral tubercles of segments three to seven inclusive. Tergites one to three inclusive are divided dorsally by a median longitudinal unsclerotized area forming a groove. In repose the long lateral erectile hairs are folded down into this groove, so that they fold forward more or less parallel to the main axis of the body. In life, the hair tufts may be erected into great fans at will, much as are the hair tufts (androconia) of certain male butterflies. It may be surmised, as Tonnoir (1940) has done, that these hairs serve to disseminate an odoriferous substance, perhaps a sexual attractant, though histological investigation of the tubercles bearing the hairs and the groove in which they lie would be needed to prove the point. Abdomen otherwise clothed with grey hairs, the genitalia with light yellowish hairs. Integument of thorax, including coxae, and of abdomen quite heavily pigmented. Legs and genitalia much less infuscated, yellowish.

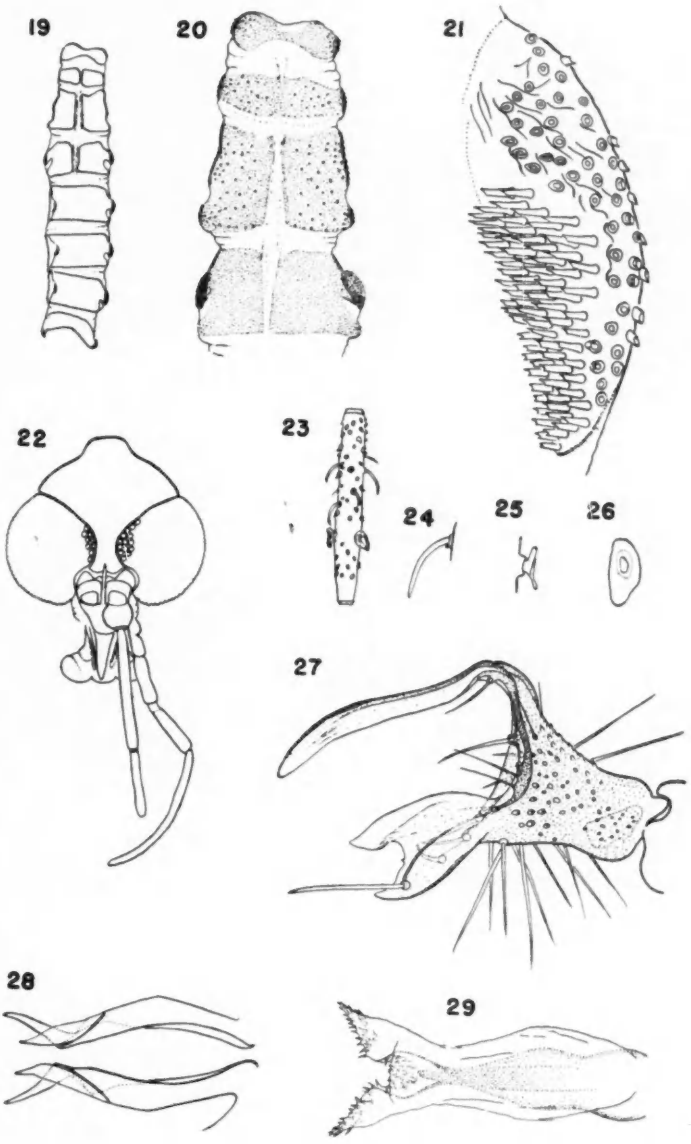
Wing venation as figured. Setae present on the upper part of the mesanepisternum, upper part of mesepimeron and upper half of sternopleuron. Head and mouth parts similar to *N. arroyoi* and *N. mopani*. Palpi and basal antennal segments as figured, ascoids and Newstead's scales essentially as in *arroyoi*. Genitalia as figured, the

EXPLANATION OF PLATE IV

Nemopalpus antillarum n. sp. Male. FIG. 19, abdomen, dorsal aspect, × 12.2; FIG. 20, same, first three tergites only, × 32.5; FIG. 21, seta bearing tubercle of abdominal tergite, dorsal view, × 269.

Nemopalpus dampfianus Alexander. Female. FIG. 22, head, × 39; FIG. 23, eighth antennal segment, × 135; FIG. 24, spinose ascoid, × 270; FIGS. 25 and 26, lateral and dorsal aspects of discoidal ascoids, × 270.

Nemopalpus sziladyi Tonnoir. Male terminalia. FIG. 27, right style, external aspect, × 135; FIG. 28, parameres, dorsal aspect, × 135; FIG. 29, aedeagus, dorsal aspect, × 135.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aedeagus longer, less spinulose, more tubular than in ***arroyoi*** and ***mopani***, but apparently of basically similar structure. In neither of the two available specimens is it well enough oriented for detailed drawing.

Holotype male, slide 1453, Sabana de la Mar, Dominican Republic, 12 June, 1949; taken in buttresses of large tree in cacao plantation 100 ft. elev., 4 km. south of town; Fairchild and Trapido colls.

Paratype male, slide 3678b, genitalia, and slide 3678a, wing, the rest of the specimen preserved dry in a vial; taken between Hato Mayor and Sabana de la Mar, Dominican Republic, 34 km. south of the latter town, under loose bark of a large tree in a coffee plantation at 650 ft. elev., 12 June, 1949; Fairchild and Trapido colls.

This species seems most closely related to *N.* ***mopani*** de Leon, from which it differs in the structure of the genitalia, especially the greatly developed parameres, in the greater length of the erectile hairs of the abdomen and in having the third tergite split. In the latter respect it is like *N.* ***sziladyi*** Tonn. from Costa Rica, but differs very much from that species in the structure of the style and parameres.

Nemopalpus dampfianus Alexander

Figs. 12, 13, 21–25, 36

1940, Rev. Ent., 11: 796–798, figs. 2, 4 (1 ♂; Finca Vergel, Chiapas, Mexico, May). Barretto and d'Andretta, 1946, Livro homenagem a R. F. d'Almeida, no. 6, p. 59 (in key).

Female.—Wing length 3.87 mm. Venation as figured. Head with vertex rather prominent. Eyes large, narrowly separated above antennal bases. Proboscis shorter than first three palpal segments. Labella large and fleshy, mandibles not discernible, maxillae membranous at tips. Cibarium without chitinous arch, unarmed. Pharynx slender, well sclerotized, unarmed. Newstead's scales pigmented, interspersed among thickly set short stout spines over about the basal two-thirds of third palpal segment. Antennal segments shorter than in *N.* ***mopani*** and ***arroyoi***, the ascoids relatively larger, bladder like, two pairs on the first flagellar segment, one pair on at least the next ten flagellar segments, the remainder of the antennal segments missing.

Dorsum of thorax heavily pigmented, pleura moderately so. No pleural setae. Wings with dark hair tufts at least on the main cross

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EXPLANATION OF PLATE V

Nemopalpus arroyoi de Leon. Basal antennal segments and palpi. Fig. 30, male; Fig. 31, female, both × 67.

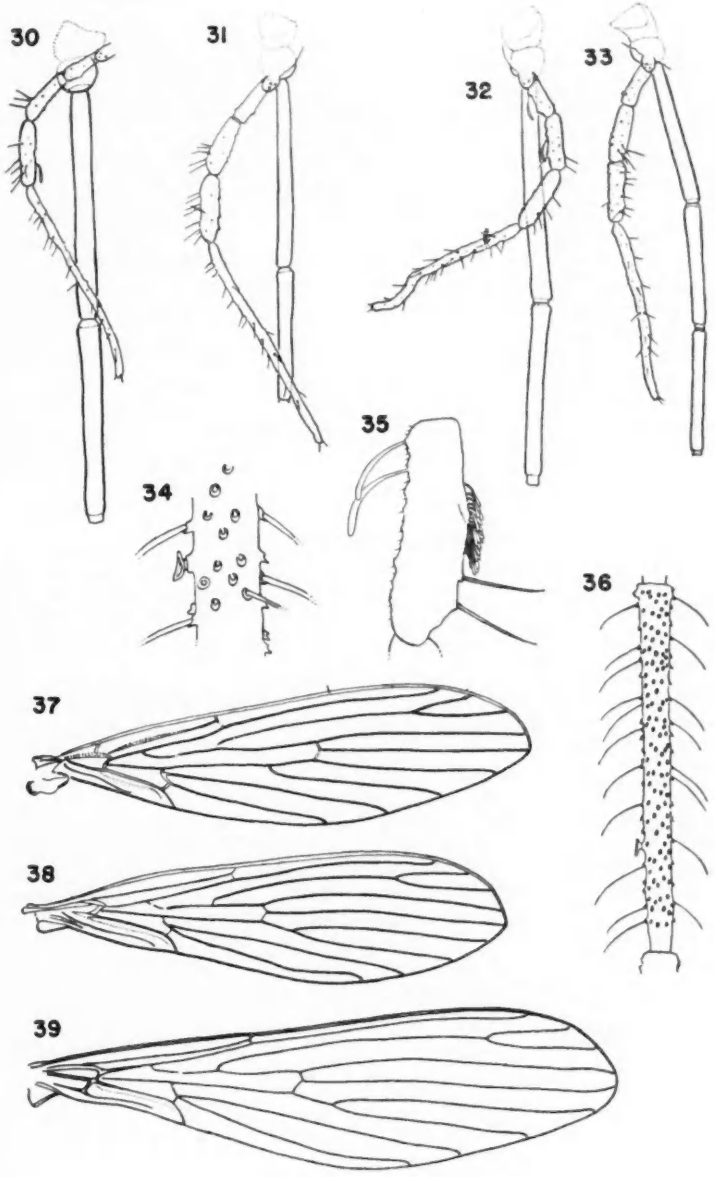
N. antillarum n. sp. Fig. 32, basal antennal segments and palpi of male, × 67.

N. mopani de Leon. Fig. 33, basal antennal segments and palpi of female, × 67; Fig. 34, part of fifth antennal segment showing ascoid, × 270; Fig. 35, third palpal segment showing Newstead's scales, × 232; Fig. 36, fifth antennal segment, × 135.

N. dampfianus Alexander. Fig. 37, wing, × 18.6.

N. antillarum n. sp. Fig. 38, wing, × 18.6.

N. arroyoi de Leon. Fig. 39, wing, × 18.6.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veins. Legs as in *N. mopani*. Abdomen quite heavily pigmented, clothed with semi-erect setae, the second sternite much broader than long. Spermatheca absent, at least no structure comparable to that found in *N. mopani* and *N. arroyoi* is present, though it may well have been lost during mounting. Terminalia as figured, quite distinct from those of the other species considered here, and lacking the ventral heavily sclerotized "gland" of *arroyoi*.

Material examined: 1 female, slide 2972, Palenque, Chiapas, Mexico, 28 March, 1951; taken between the buttressed roots of a large tree in swampy forest on the outskirts of the village of Palenque; Fairchild and Hartman coll.

This specimen is believed to be the female of *N. dampfianus* mainly on the basis of the wing venation and the presence of dark hair tufts on the wings, noted before mounting. The Type locality of *dampfianus* is near Huixtla, in the southeastern part of Chiapas, while Palenque is in the northern part, but both are at relatively low elevations and have rather similar climate, judging by the vegetation.

Aside from the venation and terminal abdominal structure, the absence of pleural setae sets this species quite apart from the other Central American forms. No mention of pleural setae appears in the descriptions of other species.

Bruchomyia Alexander

1920, Ann. Ent. Soc. Amer., 13: 402–405; genotype *B. argentina* Alex. Edwards, 1921, Ann. Mag. Nat. Hist., (9)7: 437–439. Alexander, 1929, Proc. U. S. Nat. Mus., 75(7): 1–9, 2 figs. Tonnoir, 1939, Brit. Mus. Ruwenzori Exped., 1934–5, 1(4): 37–38; 1940, 6th Congr. Intern. Ent., Madrid, 1935, p. 211. Barretto and d'Andretta, 1946, Livro homenagem a R. F. D'Almeida, no. 6, pp. 66–68.

This genus appears to be limited to the southern part of South America, extending north to about the latitude of Lima, Peru, on the west and the State of Ceara, Brasil, on the east. It is as yet unrecorded from Chile

Bruchomyia may be distinguished from any of the Neotropical species currently placed in *Nemopalpus* by the long Cu_1, which generally bears a short spur to the margin before its end, by having more than 16 antennal segments, and by the simpler genitalia. The species are all very similar and have been distinguished on relatively small differences in wing venation, number of antennal segments, genitalic details and color characters. It is quite possible that with the accumulation of more material some of the characters now depended upon for specific separation will prove unsatisfactory. The eight species so far described

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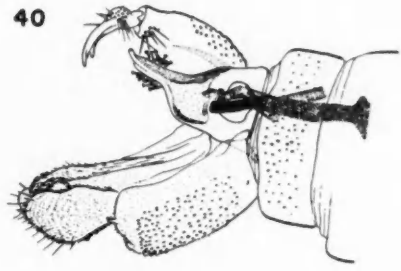
EXPLANATION OF PLATE VI

Bruchomyia fusca Barretto. Male terminalia. FIG. 40, lateral aspect, right coxite and style removed, × 67; FIG. 41, aedeagus, dorsal aspect, × 135; FIG. 42, coxite and style, inner aspect, × 200.

Bruchomyia shannoni Alexander. Male terminalia. FIG. 43, lateral aspect, right coxite and style removed, × 67; FIG. 44, dorsal aspect, semi-diagrammatic, × 67; FIG. 45, apex of coxite and style, inner aspect, × 200.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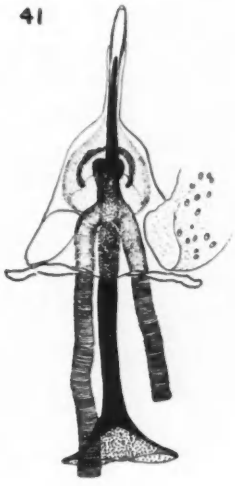
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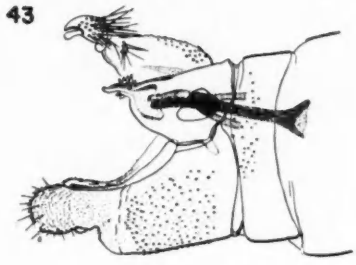
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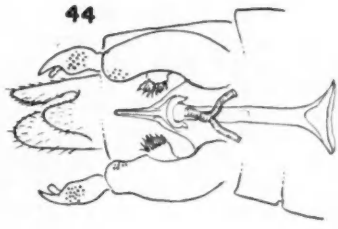
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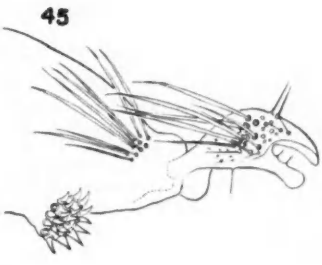
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are listed below but it has been found impossible to construct a satisfactory key based on structural character to these species from the available descriptions.

CHECK LIST OF SPECIES OF BRUCHOMYIA

almeidai Barretto and d'Andretta 1946, Livro homenagem a R. F. d'Almeida, no. 6, pp. 68–71, figs. 10–13 (♀; S. Paulo, Brasil). Barretto 1950, Pap. Avulsos Dept. Zool. Secret. Agric. S. Paulo, 9 (22): 343–346, figs. 9–13 (♂; S. Paulo).

argentina Alexander 1920, Ann. Ent. Soc. Amer., 13: 405, figs. 1–9 (♂; Prov. Cordoba, Argentina).

brasiliensis Alexander 1940, Rev. Ent., 11 (3): 795–796, figs. 1, 3 (♂; Ceara, Brasil).

fusca Barretto 1950, Papeis Avulsos Depto. Zool. Secr. Agric. S. Paulo, 9(22): 348–349, figs. 6–9 (♂; S. Paulo, Brasil).

peruviana Alexander 1929, Proc. U. S. Nat. Mus., 75 (7): 6 (♀; Colonia Perene, Chanchamayo, Peru).

plaumanni Alexander 1944, Rev. Ent., 15 (3): 313–315, figs. 1–2 (♂; Santa Catarina, Brasil).

shannoni Alexander 1929, Proc. U. S. Nat. Mus. 75 (7): 4 (♂, ♀; Verrugas Canyon, Lima, Peru).

unicolor Barretto 1950, Pap. Avulsos, Dept. Zool. Secr. Agric. S. Paulo, 9 (22): 347–348, figs. 14–16 (♂; Sao Paulo, Brasil).

Bruchomyia fusca Barretto

Figs. 39–41, 45–51

1950, Papeis Avulsos Depto. Zool. Secr. Agric. S. Paulo, 9 (22): 348–350, figs. 6–9 (♂; Serra da Cantareira, S. Paulo, Brasil).

A series of 7 ♂ 1 ♀ taken in a rock grotto at Boa Vista, Rio de Janeiro, Brasil, 6 Feb. 1950 by my colleague, Dr. Marshall Hertig, which I believe to be this species, enables me to make some additions to Barretto's description, and to give figures of some structures of possible taxonomic significance. This material was collected in alcohol, so I am unable to describe the vestiture, but it does not appear as though the wings bore contrasting markings. The series is quite variable in regard to the length of the third antennal segment and the position of the r-m cross vein in relation to the bifurcation of M_1–M_2, characters hitherto considered sufficiently stable to be used for specific differentiation. In the case of the antennae, the third segment usually is about twice as long as the fourth, but the ratio third–fourth varies from 1.6 to 2.5. Four specimens have the third segment relatively

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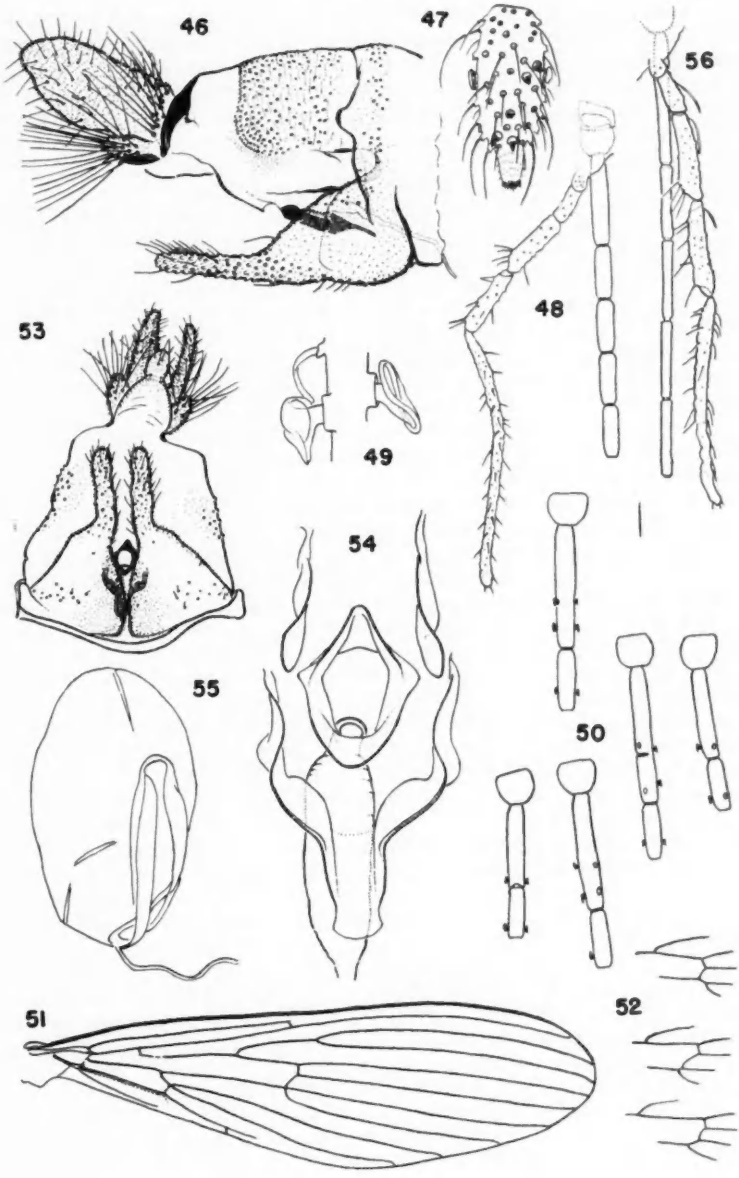
EXPLANATION OF PLATE VII

Bruchomyia fusca Barretto. FIG. 46, female terminalia, lateral aspect, × 67; FIG. 47, terminal antennal segment of male, × 270; FIG. 48, basal antennal segments and palpus, male, × 67; FIG. 49, ascoids, lateral aspect, showing spinose and discoidal types, × 604; FIG. 50, basal antennal segments of three male specimens, the single one showing the normal proportions, the other two pairs showing the variations mentioned in the text, all × 67; FIG. 51, wing of male, × 18.6; FIG. 52, variations in position of r-m in relation to fork of M_1–M_2 in different specimens, × 18.6.

Bruchomyia shannoni Alexander. FIG. 53, female terminalia, ventral aspect, × 67; FIG. 54, sclerotized structures surrounding genital opening, ventral aspect, × 270; FIG. 55, spermatheca, × 400; FIG. 56, basal antennal segments and palpus of female, × 67.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long, the ratio being greater than 2, two have it short, the ratio less than 2, while three have the third segments markedly unequal on the two sides. In one of these the suture between the third and fourth segments is incomplete on one side. In those specimens having the third segment relatively long, there are two pairs of ascoids on this segment, while in those having the third segment short, there is but a single pair of ascoids, as on the remaining segments. In the specimens with unequal segments, two have a single pair of ascoids on the short side, two pair on the long side. The third specimen has one side short, with a single pair of ascoids, the other side with the suture between the third and fourth segments incomplete, this suture falling between the two pairs of ascoids. This unstable condition may indicate the method by which ***Eutonnoiria edwardsi*** (Tonn.) achieved its very numerous antennal segments. Unfortunately, in only one specimen of this series, a male, is there a complete antenna, of 31 segments, so it is not possible to say whether this species shows the variability in number of antennal segments demonstrated for *B. shannoni*, though it is a likely possibility.

In the case of the position of the r-m cross vein relative to the bifurcation of M_1–M_2, several specimens have the cross vein joining M_1 precisely at the bifurcation, as in *shannoni*, while in others the junction may be either proximal or distal to the bifurcation.

Coxite rounded externally, apparently deeply grooved on the internal aspect, where there is a long tapering strip of sclerotization extending from the base of the coxite to beyond the internal tuft of setae. This strip bears an internal flat strip of sclerotization joined at right angles to the internal surface of the coxite and acts as an apodeme for the attachment of muscles. This structure is not well shown in the figure of coxite and style, and has been omitted to avoid confusion in the figures of the aedeagus.

Aedeagus a hollow sclerotized cone, probably the modified 8th sternite, lying between the bases of the coxites. The coxites appear to be inserted dorsolaterally near the base of this cone, in cleared preparations their places of attachment form windows in the cone. Within the cone there lies a smaller sclerotized hollow hemisphere, its apex drawn out to form the tubular intromittent organ. Into its open base is inserted the distal end of the sperm pump plunger, to which is attached near the apex the paired vasa deferentia, so that the whole structure no doubt corresponds to the sperm pump and genital filaments of *Phlebotomus*.

The 9th tergite arises slightly anterior to the base of the aedeagus, its anterior angles apparently attaching to a pair of horns arising from the lateral margins of the cone. The inner, upper surface of the 9th tergites is largely membranous, but bears a median sclerotized strip which is joined to the thickened lower margin of the aedeagal cone. This strip extends posteriorly to form the pygidium lying between the cerci. There are no lateral lobes, unless a pair of very small finger-like processes arising laterally from the membrane between the more sclerotized part of the 9th tergite and the base of the cerci can be considered incipient lateral lobes. Homologues of these protuberances are also found in

the female, but the large setiferous knobs lying laterally at the base of the cerci in the female, seem totally wanting in the male.

The spermatheca of *fusca* is indistinguishable from that of *shannoni*, consisting of a large thin-walled roughly spherical sac one side of which bears a long slit like an elongated button hole, bordered by two broad sclerotized strips. The duct is very slender and long, tenuous and thin walled.

Bruchomyia shannoni Alexander

Figs. 42–44

1929, Proc. U. S. Nat. Mus., 75 (7): 4–6, figs. 1–2 (5 ♂, 1 ♀; Verrugas Canyon, Dept. of Lima, Peru, April). Alexander, 1940, Rev. Ent., 11 (3): 795 (in key). Barretto and d'Andretta, 1946, Livro homenagem a R. F. d'Almeida, no. 6, p. 67 (in key).

A series of 6 ♂ and 7 ♀ from Surco and Tornamesa in the Rimac Valley above Lima, Peru, enables me to make some additions to Alexander's description of this species. The two teeth of the style appear to be shorter and blunter than in any of the other described species, while the setae in the tuft on the inner aspect of the coxite are very short, almost conical, and do not have the frayed or multiple branched tips of some of the other species. The position of the r-m cross vein in relation to the forking of M_1–M_2 is very constant in my material, the cross vein arising at or exceedingly close to the fork in all cases. The number of antennal segments varies somewhat, the three males in the series with complete antennae showing 27, 29 and 29 segments, the last three rather abruptly shortened. The five females with complete antennae show two with 26 segments and three with 27. The length of the third segment relative to the fourth also is rather variable, the ratio third–fourth varying from 1.5 to 2.0 in the females and 1.33 to 1.38 in the males. The ascoids appear to be of two sorts, discoidal or sac-like organs, and short curved hollow seta-like structures. Of the first, the females appear to have a pair on each flagellar segment, perhaps more on the first flagellar (segment 3), while in the males only one per segment can be made out. These discoidal ascoids are quite near the distal end of each segment. The seta-like ascoids are more numerous and scattered about on the segments. Newstead's scales are present in a diffuse patch on the middle third of the third palpal segment.

This species is not uncommon in the Verruga zone of the Rimac valley in Peru, being quite often taken resting in dark corners of houses and in shallow caves in company with *Phlebotomus*. Dr. Aristides Herrer of the Instituto de Hygiene in Lima has discovered that the immature stages are apparently passed in leaf mold, as a number of specimens emerged from litter collected from beneath pepper trees in the Verruga zone. It is hoped that he will be able to secure larvae in the near future.

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THE STUDY OF INSTINCT, by N. TINBERGEN. xii+228 pages, 130 figures. 1951. Oxford University Press, London. Price, $7.00.

The entomologist, no matter what his specialty, must deal in one way or another with the instinctive behavior of the objects of his study. Too busy with more "practical" affairs, he rarely stops to consider the *how* or the *why* of innate behavior: and yet here is a problem not only of immense intrinsic interest, but one which, if more fully studied, might shed light on many aspects of entomology, even the most practical. Most of us are familiar with Loeb's work on tropisms and with the admirable, if somewhat subjective, studies of Fabre and his followers. Many of us are not fully informed on the advances which have been made in Europe in recent years in the objective study of animal behavior. One of the avowed purposes of the present book is to call the attention of Anglo-Americans to this research, much of it published in German or other languages and in a variety of journals, not all of which are available in most libraries.

Professor Tinbergen's "The Study of Instinct" is, however, much more than this. It is a remarkably lucid summary of present knowledge in the field of innate behavior of animals, notably free of the jargon of the psychologist, drawing its examples from many groups of animals, not excluding insects. The book is an extension of a series of lectures given by the author in New York in 1947, under the auspices of the American Museum of Natural History and Columbia University. Especially concerned with the causal aspects of behavior, Tinbergen deals at some length with the reactions of animals to various external stimuli, particularly various types of "innate releasing mechanisms," as well as the reactions of animals to internal stimuli such as hormones and intrinsic central nervous factors. Orientation is considered briefly, as is the role of learning. The heirarchical organization of instincts is explained, a concept which makes possible a more meaningful analysis of complex behavior patterns than has hitherto been possible.

Taxonomists will be particularly interested in Tinbergen's last two chapters, entitled "The Adaptiveness of Behaviour" and "The Evolution of Behaviour," particularly in his discussion of homologization of behavior patterns and their use as systematic characters, both on the level of the species and subspecies and in the higher categories. If the book, in the final analysis, leaves one with some feeling of frustration, it is only because our knowledge in this vast and potentially highly rewarding field is so rudimentary. Professor Tinbergen's book should do much to stimulate thought and research in the field. Insects, so abundant both in species and in individuals, and exhibiting instinctive behavior in all degrees of simplicity and complexity, offer endless possibilities for detailed, objective studies of innate behavior. Conversely, a fuller understanding of the modes and mechanisms of behavior might serve the entomologist well in every aspect of his subject: taxonomic, physiological, ecological, and even economic.

—HOWARD E. EVANS.

LARVAE OF SOME GENERA OF COSSONINAE

(Coleoptera: Curculionidae)

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Agricultural Research Administration,
United States Department of Agriculture

The Cossoninae is a moderate-sized subfamily of the Curculionidae. The species placed in it are usually small and live rather obscurely in dead or dying wood or woody tissues. They are found frequently in the hard, dry sapwood exposed by scars on the sides of standing deciduous trees. In so far as can be ascertained from casual observations, the size or seriousness of the wound on the tree is not augmented in any way by the feeding, although the introduction of organisms causing rot may be hastened. The infestation in each of these scars, which may include two or three species of weevils living together, continues as long as sufficient nutriment remains to support the colony. Only a few of the species of the subfamily have an economic significance. *Hexarthrum ulkei* Horn is sometimes destructive to finished woodwork in buildings, the injury having much the same appearance as that caused by powder-post beetles of the families Anobiidae and Lyctidae. *Pselactus spadix* (Hbst.) is of somewhat less importance, but has been found in pilings and in damp woodwork under buildings.

Only a few papers have been published which include descriptions of or keys to larvae of this subfamily. The most important are two by Gardner (1934, 1938) which include descriptions and figures of the cossonine larvae as well as other known weevil larvae of India.

The subfamily is considered to have a phylogenetic importance at least on the basis of characters of the adults, since it is believed to show affinities with certain of the Scolytidae. Larvae of some of the scolytids might easily be mistaken for larvae of Cossoninae, but there is at present no evidence, based on larval characters, that the cossonines are more similar to the scolytids than are other groups of the Curculionidae. Larvae are known for only a small proportion of the described genera of Cossoninae, but a sufficiently large proportion of the North American genera is known to justify an attempt to separate them on larval characters. Any conclusions regarding the interrelationships between genera and groups of genera as interpreted from larval characters must, of course, be considered tentative. On the other hand, a few of the discrepancies in the arrangement of the genera on larval characters as compared with that on characters of the adults may be worth consideration by workers on the adults.

The subfamily is a fairly compact one, but as in any group as complex as the weevils, the inclusion or exclusion of certain anomalous genera will be a matter of personal opinion on the part of the investigator. As was stated in a previous paper (Anderson, 1948), the

Cossoninae appear to have a direct relationship with the Stromboscerinae on the basis of larval characters, and through the Stromboscerinae a somewhat less direct relationship with the Rhynchophorinae. Likewise the larvae of the Rhynchophorinae have basic similarities with those of the Hylobiinae and related groups. A parallel relationship is to be expected on the basis of characters of the adults, and this appears fairly definite when it is noted that certain genera, such as *Anchonus*, have been considered at times to belong to the Hylobiinae and at others in the Cossoninae.

A paper dealing with the Hylobiinae, Cholinae, and smaller, related groups is in preparation which will contain a short key to these apparently interrelated subfamilies. For the present it is believed that the following characterization will serve to indicate the distinguishing features of the larvae of the Cossoninae. All larvae studied are in the collections of the United States National Museum.

Subfamily **Cossoninae**

Posterior end of body not obviously concave dorsally and without projections. Head free.[1] Frontal suture incomplete. Frons with four or five pairs of setae, seta 5 subequal in length to or longer than 4, never distinctly shorter. Antenna consisting of one membranous article which bears several minute processes or setae and a conical to subconical accessory sensory appendage. Paired lateral and unpaired median sensillae present on labrum. Epipharynx usually with three anterolateral setae, rarely with two (*Stenomimus*) or four to five (*Oodemas*), the setae simple (*i.e.*, not branched, although in *Anchonus* the setae have minute serrations). Postmentum with three pairs of setae, the setae of posterior pair separated by a distance usually subequal to or greater than that between the setae of middle pair. Mala with five ventral and six or seven, rarely nine (*Syagrius*) dorsal setae, the setae simple. Thoracic spiracle bicameral (except *Hexarthrum*), the orifice not an elongate slit with parallel margins. Sternum usually with one pair of setae, occasionally with two or more than two pairs, the setae moderately long to long. Abdomen with eight pairs of spiracles, the peritremes subcircular, the spiracles oriented so that the air tube or tubes are directed posteriad or nearly posteriad. Eusternum with two setae, the more lateral seta often distinctly shorter than the more ventral one. Anus terminal or rarely subterminal (Anchonini), often small and subdorsal.

Larva moderately slender to moderately robust, curved, subcircular in cross section, of nearly equal thickness throughout. Head approximately as broad as long, broadest near or behind the middle, broadly oval to broadly rounded posteriorly, rarely submarginate (*Heteramphus*). Five dorsal epicranial setae present, seta 1 usually moderately long to long and subequal to or longer than seta 2, rarely seta 1 minute (*Heteramphus*). Two lateral epicranial setae present, seta 1 short to long, usually subequal to 2. Two ventral epicranial

[1]The terminology used throughout the descriptions is the same as outlined in my 1947 paper with one exception. At the suggestion of Dr. van Emden I have used sensilla (plural: sensillae) in place of sensillum (plural: sensilla).

setae present. Four minute posterior epicranial setae present. Anterior ocellus usually present. Clypeus with two setae and a sensilla on each side, near base (except the available larvae of *Hexarthrum* with three setae on each side but without sensilla). Labrum occasionally subtriangular, usually subtransverse, with anterior margin not emarginate. Labral rods moderately long to long, subparallel to slightly convergent posteriorly, rarely united posteriorly by a transverse bridge (*Phloeophagosoma*). Epipharynx with six anteromedian setae and four median spines (except *Acamptus*). Epipharyngeal sensory pores usually in two groups, the anterior group located in front of the median spines or between the anterior and posterior pairs of spines, the posterior group (absent in *Nesotocus*, *Heteramphus*, and *Syagrius*) located behind the median spines but between the labral rods. Epipharynx without asperities (except *Anchonus*, *Syagrius*, *Nesotocus* and *Heteramphus*). Outer surface of mandible with two setae. Labial palpus usually with two articles, rarely with one. Ligula with four setae. Maxillary palpus with two articles, the basal article with seta.

Pronotum with ten or eleven setae. The air tube or tubes of thoracic spiracle moderately distinct. Prodorsum of mesothorax and metathorax with one seta. Postdorsum of mesothorax and metathorax with four (except *Cossonus concinnus*, *crenatus* and *corticola*, with five) or, rarely, three setae. Alar area distinguishable, with one short to moderately long seta (except the species of *Cossonus* enumerated above). Epipleurum and pleurum on mesothorax and metathorax with one seta (except some specimens of *Cossonus concinnus*, with two). Pedal area with four to seven or, rarely, nine (*Syagrius*) setae.

Typical abdominal segments with three, four or five dorsal folds and five, four or three (*Stenomimus*) postdorsal setae. Prodorsal seta present on typical abdominal segments. Spiracular area with two setae. Epipleurum and pleurum each with two setae, one usually shorter than the other. Pedal area present (except *Heteramphus*). Sternellum usually present. Asperities simple, usually inconspicuous.

KEY TO TRIBES OF COSSONINAE

1. Labial palpus with one article; pedal area of typical abdominal segments present or absent, without a seta; pedal area of thoracic segments with four or five setae. . . . . **Trypetini** (p. 283)
   Labial palpus with two articles (except *Stenomimus*); pedal area of typical abdominal segments present and with a seta; pedal area of thoracic segments with six or more than six setae (except *Cossonus lupini*, with five). . . . 2
2. Epipharynx with eight or ten median spines, the spines arranged in two subparallel rows (fig. 19). . . . . **Acamptini** (p. 286)
   Epipharynx with four median spines (figs. 17, 18, 20–22). 3
3. Spiracles on abdominal segment VIII clearly dorsal in position and larger than those on the anterior segments (figs. 7, 12); epipharynx with moderately distinct asperities (fig. 17). . . . . **Anchonini** (p. 288)
   Spiracles on abdominal segment VIII lateral in position and not larger than those on the anterior segments (fig. 1); epipharynx without discernible asperities (figs. 18, 20–22). . . . . **Cossonini** (p. 292)

Tribe **Trypetini**

Frons with four pairs of setae. Dorsal epicranial seta 3 near frontal suture on epicranium. Epipharynx with four median spines and with at least a few asperities. Labial palpus with one article.

Postdorsum of mesothorax and metathorax with three setae. Pedal area on thoracic segments with four or five setae. Sternum on each thoracic segment with one pair of short to long setae. Abdominal spiracles all lateral, bicameral, subequal in size. Typical abdominal segments with three dorsal folds, fold I developed only laterally, and four postdorsal setae. Pedal area on typical abdominal segments present or absent, without seta.

Internal epicranial ridge absent. Endocarina present, one-third to one-half as long as frons. Ocellus absent. Sensillae on labrum arranged in a nearly straight, transverse line near base of labrum. Epipharyngeal setae arranged transversely. Epipharyngeal sensory pores in two clusters, typically three pores in each cluster, between or in front of anterior pair of median spines, the posterior pores not present. Mandible bifid apically, with small subapical and subbasal projections on dorsal inner margin. Premental sclerite nearly covering prementum, triangular posteriorly. Mala with seven dorsal setae, the dorsal setae arranged in a smoothly curved row.

Pronotum with ten setae. Mesothorax and metathorax with postdorsal seta 1 distinctly shorter than subequal 2 and 3.

Abdominal segment VIII with three postdorsal setae, IX with one or, *Nesotocus*, apparently two. Typical abdominal segments with postdorsal setae 1 and 3 short to very short, 2 and 4 moderately long to long. Eusternum on abdominal segments IV to VI, at least, with the more lateral seta distinctly shorter than the short to long ventral seta. Anus terminal, each lateral lobe with one seta. Asperities moderately conspicuous, generally distributed dorsally and laterally, sparser ventrally except on abdominal segments VIII and IX. Proventriculus without sclerotized wall or asperities.

The presence of a seta on the pedal lobes of the abdominal segments is a very stable character throughout the Curculionidae. The absence of the seta, as in these two genera, is disturbing and is interpreted to have a considerable significance. Probably correlated with this character is the reduction of the number of setae on the pedal areas of the thoracic segments. It is principally on the basis of the similarity in these two characters that these two genera are brought together in this tribe. There seem to be no published statements regarding any apparent similarity between adults of the two genera.

Csiki (1936) has catalogued *Heteramphus* in the tribe Cossonini and *Nesotocus* (together with *Trypetes* Schoenherr and other genera the larvae of which are unknown) in the tribe Trypetini. Since I have used the name Cossonini for *Cossonus* and its relatives I have applied the name Trypetini here, although with some reservations. It is probable that the characteristics of *Nesotocus* are quite different from those of *Trypetes* and its relatives, in which case a new tribe may need to be recognized.

KEY TO GENERA OF TRYPETINI

Dorsal epicranial seta 1 long (fig. 16); head dark brown, with short sublateral ridge; spiracular seta 2 on typical abdominal segments long . . I. **Nesotocus** (p. 285)

Dorsal epicranial seta 1 minute; head light orange, without sublateral ridge; spiracular seta 2 on typical abdominal segments short to very short, II. **Heteramphus** (p. 285)

I. Genus **Nesotocus** Perkins, 1900

(Fig. 16)

Larva large, robust. Head dark brown, with paired short, less heavily pigmented stripes dorsally, broadly rounded posteriorly, with short sublateral ridge extending backwards from fossa for mandible. Dorsal epicranial seta 1 long. One of the setae on spiracular area of typical abdominal segments very short, the other long. Sternellum present.

Each of the principal setae on body arising from a sclerite, the sclerites rather extensive on pedal areas of thorax and epipleural and pleural lobes. Frontal setae 1 and 3[2] short, 4 moderately long, 5 long. Antenna arising from a prominent knoblike projection from anterior margin of frons. Labral rods long, close together throughout posterior two-thirds of their length. Posterior pair of setae on postmentum separated by a distance subequal to that between the setae of middle pair.

Four of the setae on pronotum subequal, longer than the remainder. Spiracular area of mesothorax with two setae, one moderately long the other very short. Pedal area with five setae, one long, one moderately long, the remainder shorter.

Pleurum of typical abdominal segment with one of the setae short, the other long. Each lateral anal lobe with one short seta.

*N. **munroi*** Perk. Kohala Mts., Hawaii, October 2, 1929, ex *Cheirodendron*, O. H. Swezey.

*N. **kauaiensis*** Perk. Kokee, Kauai, T. H., September 7, 1946, in rotten log, K. L. Maehler.

II. Genus **Heteramphus** Sharp, 1885

Larva slender. Head light orange, depressed, subrectangular, subemarginate posteriorly, without sublateral ridge. Dorsal epicranial seta 1 minute. Setae on spiracular areas of typical abdominal segments short to very short, subequal. Sternellum absent.

Frontal seta 1 very short, 3 minute,[3] 4 very short, 5 moderately long. Labral rods short to moderately long, not close together. Posterior pair of setae on postmentum separated by a distance approximately two-thirds as great as that between the setae of middle pair.

Three of the setae on pronotum subequal, distinctly longer than the remainder. Spiracular area of mesothorax with one very short seta, the seta blunt apically. Pedal area with four setae, one extremely minute, the remainder short to moderately long, subequal.

Pleurum of typical abdominal segments with one of the setae minute, the other very short. Each lateral anal lobe with one discernible, minute seta.

*H. **swezeyi*** Perk. Olympus, Oahu, T. H., March 31, 1935, ex *Elaphoglossum gorgoneum*, O. H. Swezey.

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[2]Frontal seta 2 absent.

[3]Frontal seta 2 absent.

Tribe **Acamptini**

Dorsal epicranial seta 1 moderately long, seta 3 adjacent to frontal suture, on epicranium. Epipharynx with eight or ten median spines, without asperities. Labial palpus with two articles. Pedal area on thoracic segments with seven setae. Abdominal spiracles bicameral, all lateral, those on abdominal segment VIII not larger. Typical abdominal segments with three dorsal folds and five postdorsal setae. Setae on spiracular area of typical abdominal segments short to very short, subequal. Pedal area present on typical abdominal segments, with one short to very short seta.

This tribe is represented by material of the genus *Acamptus* only.

III. Genus **Acamptus** LeConte, 1876

(Fig. 19)

Frons with five pairs of setae. Sensillae on labrum in a nearly straight, transverse line near base of labrum. Pronotum with eleven setae of which three are long, subequal, the remainder shorter. Postdorsum of mesothorax and metathorax with four setae. One of the setae on each thoracic pedal area long, one moderately long to long, the remainder shorter. Sternum with one pair of setae. Eusternum with the setae very short, subequal. Anus terminal, not small and subdorsal.

Head orange, lighter dorsally. Internal epicranial ridge absent. Endocarina absent or very short. Frontal setae 1, 2 and 3 short to moderately long, 4 and 5 moderately long. Labrum subtriangular. Epipharynx with the anterolateral setae in a sharply curved line, the more median seta behind the other two, the anteromedian setae arranged transversely. Median spines on epipharynx in two subparallel rows. Epipharyngeal sensory pores in four clusters, two in each cluster, two clusters distinctly in front of the median spines and two clusters behind the posterior pair of median spines. Mandible with two apical teeth, without projection from dorsal inner margin but with finely ridged area on inner surface near dorsal margin. Premental sclerite complete or incomplete. Posterior pair of setae on postmentum separated by a distance subequal to or slightly shorter than that between the setae of middle pair. Mala with seven dorsal setae, the setae arranged in a smoothly curved row.

Spiracular area of mesothorax with two setae, the setae subequal and short or one of them distinctly longer than the other. Mesothorax

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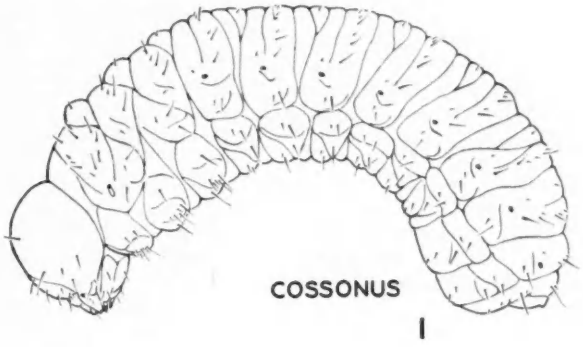
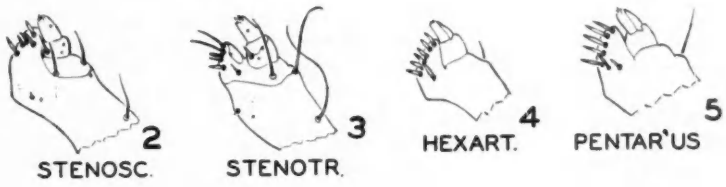
EXPLANATION OF PLATE I

FIG. 1. Lateral view of *Cossonus ponderosae*, × 13. FIG. 2. Ventral view of apical half of left maxilla of *Stenoscelis brevis*, × 160. FIG. 3. Same of *Stenotrupis prolixum*, × 100. FIG. 4. Dorsal view of apical half of right maxilla of *Hexarthrum ulkei*, × 80. FIG. 5. Same of *Pentarthrinus parvicollis*, × 160. FIG. 6. Ventral view of right mandible of *Stenotrupis prolixum*, × 100. FIG. 7. Dorsal view of abdominal segments VIII, IX and X of *Anchonus* sp., × 20. FIG. 8. Ventral view of right mandible of *Anchonus* sp., × 50. FIG. 9. Outer surface of right mandible of *Dynatopechus calandrodes*, × 100. FIG. 10. Same of *Apotrepus densicollis*, × 75. FIG. 11. Ventral view of left mandible of *Oodemas anescens*, × 75.


COSSONUS
1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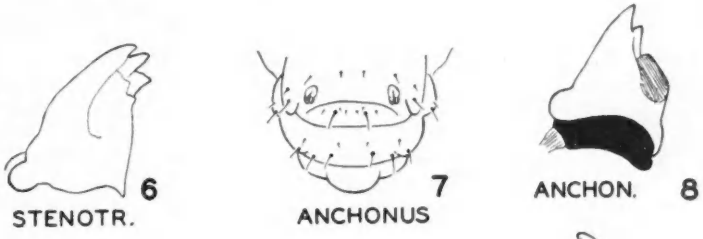
PENTAR'US


6
STENOTR.
7
ANCHONUS
ANCHON.
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DYNATOP.
9
APOTREP.
10
11
OODEMAS

and metathorax with postdorsal setae 1 and 2 short to very short, 3 and 4 moderately long to long. Setae on prosternum short to moderately long, those on mesosternum and metasternum short to very short.

Abdominal segment VIII with four postdorsal setae, IX with two. Typical abdominal segments with postdorsal setae 1, 2 and 4 short to very short, 3 and 5 moderately long. Each lateral anal lobe with three setae, one short the other two extremely minute. Asperities generally distributed over whole body, somewhat more distinct ventrally on abdominal segments VIII and IX. Proventriculus without sclerotized wall or asperities.

Larvae of several species of *Acamptus* have been studied, but since the adults cannot be identified satisfactorily, specific names are not available. The data on the specimens examined follow: Yuma, Ariz., March 26, 1945, in dead limb of pecan. Hutchinson's Island, Ga., June 26, 1945, in dead cambium of live *Platanus*, M. Gordon. Nicholson, Miss., January 20, 1945, in injury on trunk of *Liquidambar*. Nicholson, Miss., January 29, 1945, in dead *Persea*. Bloomington, Ill., Wickham Collection No. 15584.

Acamptus was originally placed by LeConte (1876, p. 238) in the Cryptorhynchini, near the Ithypori. Champion (1910), after studying genera which he considered clearly related to *Acamptus*, transferred the genus to the Cossoninae. More recently Hustache (1936) and Voss (1947) have rereferred the genus to the subfamily Cryptorhynchinae, tribe Ithyporini, subtribe Acamptina. Unfortunately close relatives of *Acamptus* are not known in the larval stage. Therefore conclusions based on larval characters must be considered tentative. However, none of the genera of the true Ithyporini available for study (*Conotrachelus*, *Aeatus*, *Chalcodermus* and *Rhyssomatus*) has larvae which have the subtriangular labrum, the mandible with a differentiated, ridged area on inner surface, nor the anterolateral setae on the epipharynx arranged as in *Acamptus*, all characteristics held in common with one or more genera in the true Cossoninae. The general appearance of the larva of *Acamptus* is typical of the Cossoninae as is its communal biology. The majority of the cossonines (all species of *Cossonus* evidently excepted) live in colonies in the host. All stages of a species will be found together, adults living and breeding entirely within the wood as long as the latter furnishes sufficient nutriment. No species of the ithyporine genera known have a similar biology, there being no evidence of community life. In view of these considerations *Acamptus* has been continued in the Cossoninae.

Tribe **Anchonini**

Frons with five pairs of setae. Dorsal epicranial seta 1 long. Dorsal epicranial seta 3 located on frons (fig. 13, des 3). Median sensilla on labrum basal, the lateral sensillae in front of labral seta 1, between or at the base of the labral rods. Epipharynx with four median spines and with moderately conspicuous asperities in the central region. Labial palpus with two articles. Postdorsum of mesothorax and metathorax with four setae. Pedal area with six or more than six setae. Sternum of each thoracic segment with one pair of setae. Abdominal

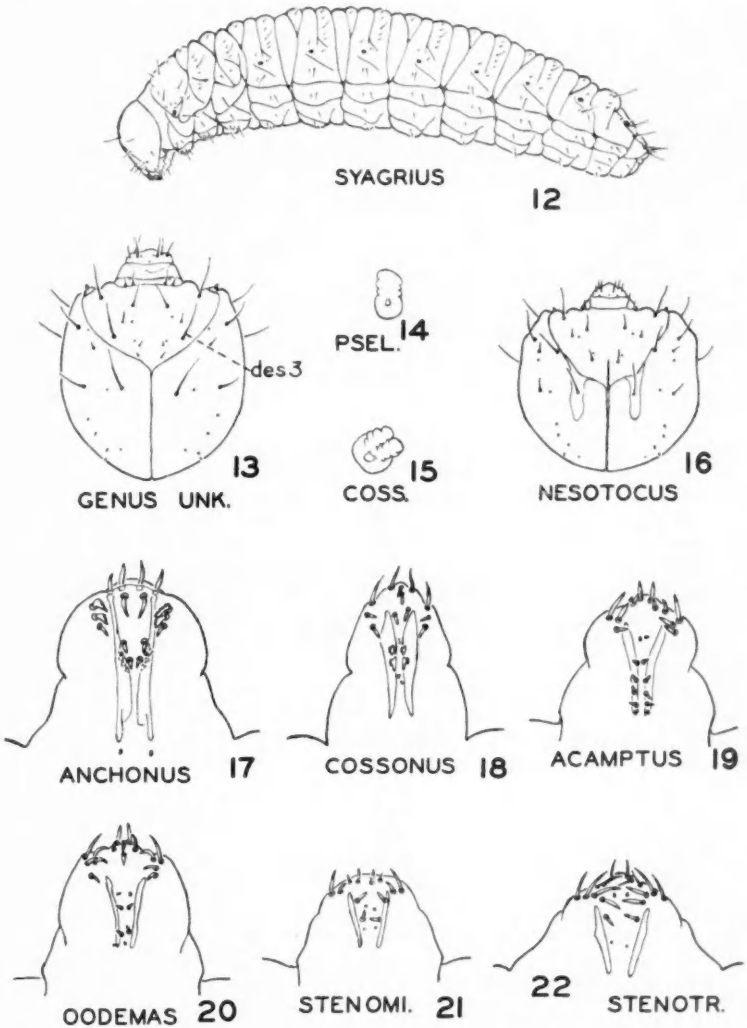

FIG. 12. Lateral view of *Syagrius fulvitarsis*, × 9. FIG. 13. Dorsal view of head of an unknown genus near *Ithaura* and *Dioptrophorus*, × 16. FIG. 14. First abdominal spiracle of *Pselactus spadix*, × 325. FIG. 15. Same of *Cossonus parallelepipedus*, × 160. FIG. 16. Dorsal view of head of *Nesotocus munroi*, × 9. FIG. 17. Epipharynx of *Anchonus* sp., × 100. FIG. 18. Same of *Cossonus concinnus*, × 85. FIG. 19. Same of *Acamptus* sp., × 100. FIG. 20. Same of *Oodemas anescens*, × 100. FIG. 21. Same of *Stenomimus pallidus*, × 325. FIG. 22. Same of *Stenotrupis prolixum*, × 100.

segments VIII and IX subconvex to slightly flattened dorsally, the spiracle on segment VIII clearly dorsal and larger than those on the anterior segments. Pedal area present on abdominal segments, with a very short to minute seta.

Internal epicranial ridge absent. Frontal setae 1, 2 and 3 usually subequal, distinctly shorter than elongate 4 and 5. Epipharynx with three anterolateral and six anteromedian setae, the anteromedian setae arranged transversely. Premental sclerite complete. The setae of posterior pair on postmentum separated by a distance shorter than that between those of middle pair.

Pronotum with eleven setae of which three are moderately long, subequal, obviously longer than the remainder. Spiracular area of mesothorax with the seta or setae very short to minute. Mesothorax and metathorax with postdorsal setae 1, 2 and 4 very short to minute, 3 moderately long to long. One of the setae on each thoracic pedal area moderately long, the remainder shorter, the most ventral seta short to very short.

Abdominal spiracles bicameral. Abdominal segment VIII with four postdorsal setae, IX with three. Typical abdominal segments with postdorsal setae 1, 2, 4 and 5 very short to minute, 3 moderately long. Setae on spiracular area short to minute. Setae on eusternum subequal, very short to minute. Anus subterminal, the lateral lobes not with elongate setae.

The genera here included in this tribe are placed in separate subfamilies on the basis of characters of the adults. Marshall (1932, p. 346) includes *Anchonus* in the Hylobiinae and (*l. c.*, p. 344) places *Syagrius* in the Rhyparosominae. The larvae of *Anchonus* appear to be quite distinct from those of the typical Hylobiinae. They differ in the orientation of the spiracles on the abdominal segments and in the shape of the spiracular orifice, the comparative lengths of postdorsal seta 5 and spiracular seta 2 on the typical abdominal segments, in the structure of the mandibles and in the details of the epipharynx. *Anchonus* differs from the Cossonini by some of the same characters listed above, namely the shape of the orifice of the spiracles and the comparative lengths of postdorsal seta 5 and spiracular seta 2 on the typical abdominal segments. However, in the orientation of the spiracles *Anchonus* approaches the Cossonini and a very striking similarity is found in the general appearance and details of the epipharynx and labrum and in the structure of the mandibles between *Anchonus* and *Cossonus*. Nowhere else in the Curculionidae have I observed an epipharynx with the unique appearance that it has in these two genera and *Mesites*. In other genera of the Cossonini there is an approach to the condition found in *Cossonus*. The structure of the mandibles is no less striking. Because of these remarkable similarities between *Anchonus* and *Cossonus* and the absence of any definite similarities between *Anchonus* and the Hylobiinae, I have included *Anchonus* in the Cossoninae.

Marshall (1932a) has included with *Anchonus*, in the subtribe Anchonina, several genera, among them *Ithaura* and *Dioptrophorus*, with representatives in Mexico, Central America and northern South America. Although larvae of neither of these genera are available for study we have a few larvae of an interesting undetermined genus

from Mexico, reported as found in sweet potatoes. Associated adults are obviously related to *Ithaura* and *Dioptrophorus* and except for the mandibles and epipharynx the larvae show distinct similarities to larvae of *Anchonus*. The principal similarities lie in the relative lengths and positions of the setae on the head, thoracic and abdominal segments and the position and orientation of the spiracles on abdominal segment VIII. Perhaps the most significant of these similarities is the position of dorsal epicranial seta 3, on the frons, and the appearance of the spiracles on abdominal segment VIII.

A similar or identical set of the characters which are held in common between *Anchonus* and the larvae from sweet potatoes, is found in the larva of *Syagrius* as well as in a single undetermined but obviously related larva from New Zealand. *Syagrius* is placed in the Rhyparosominae on the basis of characters of the adults although the adult bears a distinct resemblance to *Anchonus*. It is unfortunate that the larva of *Rhyparosomus* is not available for study. It is probable that it will be quite unlike that of *Syagrius* and may well show affinities with *Listroderes*.

KEY TO GENERA OF ANCHONINI

1. Mandible with prominent molalike projection on dorsal inner margin (fig. 8); typical abdominal segments with three dorsal folds; anterolateral setae of epipharynx in nearly straight longitudinal lines (fig. 17). . . . . IV. **Anchonus** (p. 291)
   Mandible without molalike projection; typical abdominal segments with four dorsal folds; anterolateral setae on epipharynx arranged transversely. 2
2. Mala with seven dorsal setae; endocarina absent. . . . . V. **Undetermined genus,** near *Ithaura* and *Dioptrophorus* (p. 292)
   Mala with eight or nine dorsal setae; endocarina present, approximately one-third as long as frons. . . . . VI. **Syagrius** (p. 292)

IV. Genus **Anchonus** Schoenherr, 1826

(Figs. 7, 8, 17)

Head light orange, as broad as long, broadly oval posteriorly. Frontal suture not distinguishable posteriorly, vague anteriorly. Endocarina absent. Antenna overhung dorsally by a shelflike prolongation of frons. Labrum pigmented throughout, subtriangular, as long as broad, the anterior margin produced in the middle. Anterolateral setae on epipharynx in nearly straight, anteroposterior lines, the individual setae fan shaped, with minute serrations. Epipharyngeal sensory pores in two clusters, three in each cluster, placed between the anterior and posterior pairs of median spines. Mandible bifid apically and with prominent molalike projection on dorsal margin, the projection finely, longitudinally carinate on inner surface. Premental sclerite with or without vague anterior and posterior median extensions. Mala with seven dorsal setae.

Spiracular area of mesothorax with one very short seta.

Typical abdominal segments with three dorsal folds. Asperities on body fine, arranged in short comblike rows or as individual points.

Description based upon several lots of larvae, none of which can be identified to species, from the Canal Zone, attacking telegraph poles, and the Bahama Islands, in dead mulberry wood.

V. **Genus undetermined**

(near *Ithaura* Pascoe and *Dioptrophorus* Faust)

(Fig. 13)

Larva moderately robust. Head reddish orange, without paired, nonpigmented stripes dorsally, as broad as long, oval posteriorly. Frontal suture distinct throughout its length, not sharply angulate posteriorly. Endocarina absent. Labrum broader than long, the anterior margin slightly produced in the middle. Anterolateral setae on epipharnyx transversely arranged, the setae simple. Epipharyngeal sensory pores in four groups, two groups, each containing two pores, in front of the anterior pair of median spines, and two groups, each containing one pore, between anterior and posterior pairs of spines. Mandible bifid apically, without evidence of molar area. Premental sclerite with distinct anterior and posterior median extensions. Mala with seven dorsal setae.

Shorter setae on pronotum short to very short. Prodorsal setae on mesothorax and metathorax short. Mesothorax and metathorax with postdorsal setae 1, 2 and 4 short. Seta on alar area short.

Typical abdominal segments with postdorsal setae 1, 2, 4 and 5 short, 3 long. Spiracular area with seta 1 very short, seta 2 short. Setae on pedal and eusternal areas short. Asperities moderately conspicuous, occurring as individual points.

Description based upon two lots of larvae from Mexico, in sweet potatoes and one lot from Mexico in *?Boussingaultia*.

VI Genus **Syagrius** Pascoe, 1875

(Fig. 12)

Larva slender. Head reddish brown with paired dorsal, longitudinal, nonpigmented stripes, slightly longer than broad, oval posteriorly. Frontal suture distinct throughout its length, angulate posteriorly. Endocarina present, approximately one-third as long as frons. Labrum distinctly broader than long, the anterior margin only slightly produced in the middle. Anterolateral setae on epipharynx transversely arranged, the setae simple. Epipharyngeal sensory pores in two clusters, three in each cluster, placed between the anterior and posterior pairs of median spines. Mandible bifid apically, without evidence of molar area. Premental sclerite with distinct anterior and posterior median extensions. Mala with eight or nine dorsal setae.

Spiracular area of mesothorax with two or three setae, one very short the other one or two very minute.

Typical abdominal segments with four dorsal folds. Asperities on body minute, occurring as individual points, generally distributed dorsally and ventrally.

S. fulvitarsis Pascoe. Nahiku, Maui, August 20, 1929, ex *Sadleria* fern, O. H. Swezey. Honolulu, ex ferns, O. H. Swezey.

Tribe **Cossonini**

Epipharynx with four median spines, without asperities. Labial palpus with two articles, except *Stenomimus*, with one. Pedal area of

thoracic segments with six or seven setae, except *Cossonus lupini*, with five. Abdominal spiracles unicameral or bicameral, all lateral, those on abdominal segment VIII not larger than those on the anterior segments. Pedal area present on typical abdominal segments and with a seta.

Frons with four or five pairs of setae. Dorsal epicranial seta 1 subequal to or slightly longer than seta 2, seta 3 very rarely on frons. Lateral sensillae on labrum located between bases of labral rods. Premental sclerite occasionally vague or interrupted near the middle.

Pronotum with ten or eleven setae. Spiracular area of mesothorax with two setae, rarely with three in some species of *Rhyncolus*, one seta almost always distinctly longer than the other. Sternum usually with one pair of setae, occasionally with two or more than two pairs.

Typical abdominal segments with three, four or five dorsal folds and with five, rarely four or three (*Stenomimus*) postdorsal setae. Typical abdominal segments with one of the setae on spiracular area distinctly longer than the other (except *Oodemas*, *Hexarthrum*, *Stenoscelis* and *Catolethrus*). Eusternum with the more lateral seta often distinctly shorter than the more ventral one. Anus often small and subdorsal.

While the subtribes of the Cossonini as outlined by Csiki (1936) may be for the most part natural aggregations of genera it has not been practicable to maintain them in all cases in the arrangement that follows. Attention will be called to only two of the discrepancies. The adults of *Stenotrupis* and *Pentarthrinus* are grouped, with other genera, in the Pentarthri by Csiki. However, the larvae of *Stenotrupis* have only three postdorsal setae on the mesothorax and metathorax and the larvae of *Pentarthrinus* have two pairs of setae on the sternum of the thoracic segments. These two characters, considered with other, less outstanding ones, have sufficient importance to indicate that the genera mentioned should not be placed so close together as they have been.

The apparent discrepancy in placing *Rhyncolus* and *Phloeophagus* as inseparable genera whereas Csiki has placed the former in the Rhyncholi and the latter in the Cossoni is a matter of nomenclature rather than zoology. Csiki has included the genotype of *Phloeophagus* in the genus *Rhyncolus* and included under *Phloeophagus* the species properly placed under *Pselactus*.

KEY TO GENERA OF COSSONINI

1. Epipharynx with two anterolateral setae (fig. 21); labial palpus with one article; typical abdominal segments with three postdorsal setae. . . . . VII. **Stenomimus** (p. 295)
   Epipharynx with three or four (*Oodemas*) anterolateral setae (figs. 18, 22); labial palpus with two articles; typical abdominal segments with four or five postdorsal setae. 2
2. Mesothorax and metathorax with three postdorsal setae; one of the ventral setae on mala located near base of palpus (fig. 3). . VIII. **Stenotrupis** (p. 295)
   Mesothorax and metathorax with four or apparently five postdorsal setae (except *Cossonus lupini*, with three); ventral setae on mala normal in position (fig. 2). 3
3. Sternum of at least one thoracic segment with two or more than two pairs of setae. 4
   Sternum of each thoracic segment with one pair of setae. 7
4. Epipharynx with four (or five) anterolateral setae, three of which are in a nearly straight longitudinal line (fig. 20); typical abdominal segments

with spiracular seta 2 subequal in length to postdorsal seta 4, not more than one-half as long as seta 5 ..... IX. **Oodemas** (p. 296)

Epipharynx with three anterolateral setae; typical abdominal segments with spiracular seta 2 subequal in length to postdorsal seta 5, approximately twice as long as postdorsal seta 4 5

5. Frons with five pairs of setae; mandible without a subapical molar area, ... X. **Pentarthrinus** (p. 297)

Frons with four pairs of setae; mandible with a carinate, subapical molar area 6

6. Labral rods subparallel, united posteriorly by a transverse bridge; abdominal spiracles unicameral ..... XI. **Phloeophagosoma** (p. 298)

Labral rods slightly convergent posteriorly, not united by a transverse bridge; abdominal spiracles bicameral ..... XII. **Oxydema** (p. 298)

7. Abdominal spiracles unicameral (fig. 14); (frons with five pairs of setae) 8

Abdominal spiracles bicameral (fig. 15); (frons with five or, often, four pairs of setae) 10

8. Anus normal in position and size; typical abdominal segments with postdorsal seta 1 as long as 3, longer than 2 ..... XIII. **Pselactus** (p. 299)

Anus small, subdorsal; typical abdominal segments with postdorsal seta 1 shorter than 3, as long as 2 9

9. Thoracic spiracle unicameral ..... XIV. **Hexarthrum** (p. 300)

Thoracic spiracle bicameral ..... XV. **Stenoscelis** (p. 300)

10. Anterolateral setae on epipharynx in a nearly straight longitudinal row (fig. 18); one pair of anteromedian setae on epipharynx arranged longitudinally; labrum subtriangular, the median sensilla on labrum at or before the middle 11

Anterolateral setae on epipharynx not in a straight, longitudinal row; anteromedian setae on epipharynx arranged transversely; labrum broader, subtrapezoidal, the median sensilla on labrum basal 12

11. Posterior pair of setae on postmentum separated by a distance one-half or more than one-half as great as that between the setae of middle pair; spiracle on abdominal segment I only slightly if at all larger than on segment II ..... XVI. **Cossonus** (p. 301)

Posterior pair of setae on postmentum separated by a distance less than one-third as great as that between the setae of middle pair; spiracle on abdominal segment I obviously larger than on segment II ..... XVII. **Mesites** (p. 302)

12. Frons with five pairs of setae; typical abdominal segments with four or five dorsal folds 13

Frons with four pairs of setae; typical abdominal segments often with three dorsal folds 14

13. Mala with six dorsal setae; eusternum on typical abdominal segments with the setae short to moderately long, subequal; proventriculus without sclerotized wall or asperities ..... XVIII. **Nyssonotus** (p. 303)

Mala with seven dorsal setae; eusternum on typical abdominal segments with the more lateral seta short, the more ventral seta long; proventriculus with weakly sclerotized wall and asperities ..... XIX. **Catolethrus** (p. 303)

14. Proventriculus with sclerotized wall and asperities; typical abdominal segments with four or five dorsal folds ..... XX. **Rhyncolus** (p. 304) and XXI. **Phloeophagus** (p. 305)

Proventriculus without sclerotized wall or asperities; typical abdominal segments with three dorsal folds, except *Dynatopechus*, but the latter with endocarina present and distinct 15

15. Mala with seven dorsal setae; abdominal segment VIII with three postdorsal setae ..... XXII. **Macrancylus** (p. 306)

Mala with six dorsal setae; abdominal segment VIII with four or five (*Caulophilus*) postdorsal setae 16

16. Mandible with a granular area near base on dorsal inner margin; anteromedian setae on epipharynx in a curved, single row, the curve following the outline of anterior margin of labrum ..... XXIII. **Caulophilus** (p. 307)

Mandible without granular area; anteromedian setae on epipharynx not in a single row, two of the setae placed more posteriorly 17

17. Setae on outer surface of mandible adjacent at base (fig. 10); posterior group of sensory pores on epipharynx scattered, not occurring in a

compact cluster, the anterior pores placed between the anterior and posterior pairs of median spines.....XXIV. **Apotrepus** (p. 307)

Setae on outer surface of mandible widely separated at base (fig. 9); posterior group of sensory pores on epipharynx in a compact cluster, the anterior pores placed in front of the anterior pair of median spines.....XXV. **Dynatopechus** (p. 308)

VII. Genus **Stenomimus** Wollaston, 1873

(Fig. 21)

Frons with four pairs of setae. Epipharynx with two anterolateral setae, the setae arranged transversely. Mandible with two apical teeth and a somewhat irregular, low projection subapically on dorsal inner margin. Labial palpus with one article. Mala with six dorsal setae. Postdorsum of mesothorax and metathorax with three setae. Sternum with one pair of moderately long setae. Abdominal spiracles unicameral. Typical abdominal segments with four dorsal folds. Abdominal segments I to VIII with three postdorsal setae, IX with two, both of which are long. Proventriculus without sclerotized wall or asperities.

Head light orange, with dorsal, non-pigmented stripes which are convergent posteriorly. Internal epicranial ridge faintly discernible. Frontal suture indistinguishable posteriorly. Endocarina absent. Ocellus indistinct. Labral sensillae basal, the median sensilla slightly anterior. Anterior group of sensory pores on epipharynx consisting of two pores, placed between the anterior and posterior pairs of median spines, the posterior group consisting of two pores. Premental sclerite only slightly pigmented. Posterior pair of setae on postmentum separated by a distance slightly greater than that between the setae of middle pair.

Pronotum with ten setae. Mesothorax and metathorax with postdorsal setae 1 and 3 long, 2 short. Pedal area with six setae.

Typical abdominal segments with postdorsal setae 1 and 3 long, 2 short to very short. Seta on pedal area moderately long. Eusternum with the more lateral seta short, the more ventral seta long. Sternellum present. Anus not subdorsal. Each lateral anal lobe with two discernible setae, one extremely minute, the other short. Asperities evenly distributed over whole body.

S. pallidus (Boh.). Licking Banks, Washington, D. C., March 9, 1915, in colonies under bark of black walnut, Champion and Barber.

VIII. Genus **Stenotrupis** Wollaston, 1873

(Figs. 3, 6, 22)

Internal epicranial ridge present, distinct at least posteriorly. Frons with four pairs of setae. Epipharynx with three anterolateral setae, the setae in a nearly straight transverse line. Mandible with three apical teeth, without flattened, molalike area. Mala with six dorsal setae, one of the ventral setae on mala near base of palpus. Postdorsum of mesothorax and metathorax with three setae. Sternum with one pair of long setae. Abdominal spiracles bicameral. Typical abdominal segments with five dorsal folds, folds I, III and V with indications of plicae. Four postdorsal setae present on abdominal segments I to VII. Proventriculus without sclerotized wall or asperities.

Larva slender. Head brown, with narrow, convergent, less heavily

pigmented stripes dorsally, slightly depressed. Frontal suture distinguishable throughout its length, broader posteriorly. Endocarina absent. Ocellus absent. Labral sensillae in a nearly straight, transverse line, near base of labrum. Labral rods short to moderately long, straight, subparallel, rather widely separated. Anteromedian setae on epipharynx arranged transversely. Epipharyngeal sensory pores in two clusters, two in each cluster, in front of the anterior pair of median spines. Premental sclerite complete, with distinct anterior and posterior median extensions. Posterior pair of setae on postmentum separated by a distance subequal to that between the setae of middle pair.

Pronotum with ten setae all but one of which are moderately long to very long. Postdorsum of mesothorax and metathorax with seta 1 short, 2 and 3 very long. Alar area with one short seta. Pedal area with six setae of which two are short, two long, two very long.

Abdominal segments VIII and IX each with three postdorsal setae, two of those on segment IX very long. Typical abdominal segments with postdorsal setae 1 and 3 short to very short, 2 and 4 long to very long. Epipleurum and pleurum each with two setae, one short the other very long. Pedal area with one long seta. Eusternum with the more lateral seta short to very short, the more ventral seta long to very long. Sternellum present. Anus terminal, each lateral lobe with three setae, one minute, one long, one very long. Asperities absent.

S. prolixum (Sharp). Kahuku, Oahu, T. H., October 30, 1927, ex dead frond stems of *Cibotium menziesii*, O. H. Swezey.

IX. Genus **Oodemas** Boheman, 1859

(Figs. 11, 20)

Frons with five pairs of setae. Epipharynx with four (or five) anterolateral setae, the three inner setae arranged in a longitudinal line, one pair of anteromedian setae arranged in a longitudinal line. Mandible with two apical teeth and with granular, molalike area subapically on inner surface. Mala with seven dorsal setae, the most posterior dorsal seta out of line. Sternum with two pairs of moderately long setae. Abdominal spiracles unicameral. Typical abdominal segments with four dorsal folds and five postdorsal setae of which setae 1, 2 and 4 are short, 3 and 5 long. Typical abdominal segments with spiracular seta 2 subequal in length to postdorsal seta 4, not more than one-half as long as seta 5. Proventriculus without sclerotized wall or asperities.

Head only slightly pigmented. Internal epicranial ridge absent. Frontal suture indistinguishable posteriorly. Endocarina absent. Anterior ocellus distinct, posterior ocellus present, scarcely distinguishable. Lateral sensillae on labrum basal, median sensilla slightly anterior. Labral rods short, straight, slightly convergent posteriorly. Anterior group of sensory pores on epipharynx consisting of four pores, placed in front of median spines, the posterior group consisting of four pores. Premental sclerite interrupted near the middle but with moderately distinct anterior and posterior median extensions. Posterior pair of setae on postmentum separated by a distance subequal to that between the setae of middle pair.

Pronotum with eleven setae. Mesothorax and metathorax with

four postdorsal setae of which setae 1, 3 and 4 are long, 2 short. Pedal area with seven setae.

Abdominal segment VIII with four postdorsal setae, IX with three of which two are elongate. Seta on pedal area short. Eusternum with the setae short, subequal. Sternellum present. Anus not subdorsal, each lateral lobe with three setae. Asperities generally distributed, at least dorsally, not more conspicuous ventrally on posterior abdominal segments.

O. aenescens Boh. Olympus, Oahu, ex *Broussaisia arguta*, O. H. Swezey.

O. robustum Blkb. Pun Kaua, Waianae Mts., Oahu, November 6, 1927, ex dead wood of ohia lehua, O. H. Swezey.

X. Genus **Pentarthrinus** Casey, 1892

(Fig. 5)

Frons with five pairs of setae. Epipharynx with the setae arranged transversely. Mandible with three teeth, two of them small and subequal; mandible without carinate area. Mala with seven dorsal setae, the posterior setae in a sharply curved row. Sternum of prothorax and mesothorax (of metathorax also: *P. nitens*) with two pairs of moderately long setae. Abdominal spiracles bicameral, the air tubes slender. Typical abdominal segments with four dorsal folds, fold V protuberant in middorsal line forming ampullalike lobes, and five postdorsal setae of which 1, 3 and 5 are moderately long, subequal, 2 and 4 very short. Setae on eusternum short, subequal. Proventriculus without sclerotized wall or asperities.

Head light orange. Internal epicranial ridge absent. Frontal suture distinguishable throughout its length. Endocarina absent. Ocellus distinct. Labral sensillae basal. Labral rods moderately long, subparallel or slightly convergent posteriorly, not united by a transverse bridge. Anterior group of sensory pores on epipharynx consisting of two pores, placed in front of median spines, the posterior group consisting of four pores. Premental sclerite lightly pigmented, with vague short, anterior and posterior median extensions. Posterior pair of setae on postmentum separated by a distance slightly greater than that between the setae of middle pair.

Pronotum with eleven setae. Mesothorax and metathorax with four postdorsal setae of which 1, 3 and 4 are moderately long, 2 very short. Pedal area with six setae of which five are moderately long, subequal, one short to very short.

Abdominal segment VIII with four postdorsal setae,[4] IX with two, of which one is elongate. Seta on pedal area short. Sternellum present. Anus not subdorsal; each lateral anal lobe with three setae of which two are short, the other moderately long. Asperities not discernible.

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[4]One unidentified, but obviously closely related, specimen in the collection has five postdorsal setae on abdominal segment VIII. The specimen is associated with adults of *Pentarthrinus* and *Pseudopentarthrum*. No larvae of the latter genus are available for study so it is not possible to ascertain whether the unidentified larva is normal or abnormal.

P. parvicollis Csy. Snow Hill, Md., December 23, 1947, in dead wood of scar on holly (*Ilex*), W. H. Anderson.

Pentarthrinus sp., possibly *nitens* (Horn). University Park, Md., January 28, 1945, in dead wood of scar on tulip (*Liriodendron*), W. H. Anderson.

XI. Genus **Phloeophagosoma** Wollaston, 1873

Frons with four pairs of setae. Labral rods moderately long, subparallel, united posteriorly by a transverse bridge. Epipharynx with the inner anterolateral seta slightly behind the outer two, the anteromedian setae arranged transversely. Mandible with two apical teeth and a subapical, carinate area on inner surface. Mala with seven dorsal setae, the posterior setae in a sharply curved row. Sternum of each thoracic segment with two pairs of moderately long setae. Abdominal spiracles unicameral. Typical abdominal segments with five dorsal folds, without evidence of ampullalike swellings, and five postdorsal setae of which setae 1, 3 and 5 are long, 2 and 4 short. Proventriculus without sclerotized wall or asperities.

Head light orange. Internal epicranial ridge absent. Frontal suture indistinguishable posteriorly. Endocarina absent. Ocellus small, moderately distinct. Labral sensillae basal. Anterior group of sensory pores on epipharynx consisting of four pores, placed in front of median spines, posterior group consisting of four pores. Premental sclerite lightly pigmented, with vague anterior and posterior median extensions. Posterior pair of setae on postmentum separated by a distance slightly greater than that between the setae of middle pair.

Pronotum with eleven setae. Mesothorax and metathorax with four postdorsal setae, of which setae 1, 3 and 4 are long, 2 short.

Abdominal segment VIII with three postdorsal setae, IX with two of which one is long. Seta on pedal area long. Eusternum with the more lateral seta short, the more ventral seta long. Sternellum present. Anus not subdorsal, each lateral lobe with three setae, one very short, one moderately long, one long. Asperities generally distributed, not more conspicuous ventrally on posterior abdominal segments.

P. tenuis (Gemm.). Waipio, Oahu, T. H., March 1930, ex rotten wood, O. H. Swezey.

XII. Genus **Oxydema** Wollaston, 1873

Frons with four pairs of setae. Labral rods moderately long, slightly convergent posteriorly, not united posteriorly by a transverse bridge. Epipharynx with the anterolateral setae in a nearly straight, diagonal line, the anteromedian setae arranged transversely. Mandible with two apical teeth and with moderately prominent carinate projection on dorsal inner margin. Mala with seven dorsal setae, the posterior setae in a sharply curved row. Air tubes of thoracic spiracle slender, inconspicuous, shorter than diameter of subcircular peritreme. Sternum of prothorax with one or more than one pair of moderately long setae; sternum of mesothorax and metathorax with two or more than two pairs of long setae. Abdominal spiracles bicameral. Typical abdominal segments with five dorsal folds and with five postdorsal setae of which

1, 3 and 5 are long, 2 and 4 short to moderately long. Proventriculus without sclerotized wall or asperities.

Head light brown, with vaguely defined, less heavily pigmented area dorsally. Internal epicranial ridge absent. Frontal suture moderately distinct posteriorly. Endocarina absent. Ocellus distinct. Sensillae on labrum all basal. Anterior group of sensory pores on epipharynx consisting of four pores placed in front of median spines, the posterior group consisting of four pores. Premental sclerite with the median portion less heavily pigmented. Posterior pair of setae on postmentum separated by a distance slightly greater than that between the setae of middle pair.

Pronotum with eleven setae. Mesothorax and metathorax with four postdorsal setae of which 1, 3 and 4 are long, 2 moderately long. Pedal area with six setae.

Abdominal segment VIII with three postdorsal setae, IX with two of which one is long. Seta on pedal area long. Eusternum with the setae long, the more lateral seta only slightly shorter. Sternellum present. Anus not subdorsal, each lateral anal lobe with three setae, one moderately long, two long. Asperities generally distributed, not more conspicuous ventrally on posterior abdominal segments.

O. fusiforme Woll. Honolulu, T. H., November 16, 1927, in rotten boards on ground, O. H. Swezey. Mt. Kaala, Oahu, T. H., April 3, 1947, *Acacia koa* branch, P. W. Weber.

O. longulum (Boh.). Windward, Oahu, T. H., September 15, 1946, in dead bamboo, K. L. Maehler.

XIII. Genus **Pselactus** Broun, 1886

(Fig. 14)

Frons with five pairs of setae. Epipharynx with the anterolateral setae arranged in a diagonal line, the anteromedian setae arranged transversely. Mandible with two apical teeth and small projection on dorsal inner margin. Mala with seven dorsal setae, the most posterior dorsal seta out of line. Mesothorax and metathorax with four postdorsal setae. Sternum with one pair of moderately long setae. Abdominal spiracles unicameral. Typical abdominal segments with four dorsal folds and with five postdorsal setae of which 1, 3 and 5 are moderately long, 2 and 4 short. Anus terminal, not subdorsal, each lateral anal lobe with three setae, two very short, one short. Proventriculus without sclerotized wall or asperities.

Head orange. Internal epicranial ridge vague. Frontal suture indistinct posteriorly. Endocarina present, indistinct, approximately one-half as long as frons. Ocellus distinct. Lateral sensillae on labrum situated approximately one-third the distance from base to apex, median sensilla basal. Labral rods moderately long, subparallel. Anterior group of sensory pores on epipharynx consisting of four pores placed in front of median spines, the posterior group consisting of four pores. Premental sclerite interrupted for a short distance on each side of median piece. Posterior pair of setae on postmentum separated by a distance slightly greater than that between the setae of middle pair.

Pronotum with eleven setae. Thoracic spiracle bicameral. Meso-

thorax and metathorax with postdorsal setae 1, 3 and 4 long, 2 short. Pedal area with six setae.

Abdominal segment VIII with three postdorsal setae, IX with two, both usually long. Seta on pedal area short to moderately long. Eusternum with the more lateral seta short, the more ventral seta only slightly longer. Sternellum present. Asperities not more conspicuous ventrally on posterior abdominal segments.

P. spadix (Hbst.). Charlestown, Mass., July 1938, from top of pile, Pier 40, Hoosac Tunnel. Mount Pleasant, S. C., August 8, 1944, in dead wood of *Ficus*. Italy, June 26, 1946, in poplar wood, intercepted in quarantine at New York City.

XIV. Genus **Hexarthrum** Wollaston, 1860

(Fig. 4)

Frons with five pairs of setae. Epipharynx with the anterolateral setae in a curved, oblique row, the anteromedian setae arranged transversely. Mandible with one tooth, without a distinct carinate area subapically on dorsal inner margin, the dorsal condyle projecting and with a distinct rim. Mala with seven dorsal setae, the most posterior dorsal seta distinctly out of line. Thoracic spiracle unicameral. Mesothorax and metathorax with four postdorsal setae. Sternum with one pair of short to moderately long setae. Abdominal spiracles unicameral. Typical abdominal segments with four dorsal folds and five postdorsal setae of which 1, 2 and 4 are short, 3 and 5 moderately long. Anus small, subdorsal, each lateral anal lobe with three setae, one short, two extremely minute. Proventriculus without sclerotized wall or asperities.

Head light orange. Internal epicranial ridge present, vague. Frontal suture not discernible. Endocarina present, indistinct. Ocellus small. Median sensilla on labrum basal, the lateral sensillae placed more anteriorly. Labral rods moderately long, slightly convergent posteriorly. Anterior group of sensory pores on epipharynx consisting of four pores placed in front of anterior pair of median spines, the posterior group consisting of four pores. Premental sclerite complete, with anterior and posterior median extensions. Posterior pair of setae on postmentum separated by a distance distinctly greater than that between the setae of middle pair.

Pronotum with eleven setae. Spiracular area of mesothorax with two short, subequal setae. Mesothorax and metathorax with postdorsal setae 1, 2 and 4 short, 3 moderately long. Pedal area with six setae.

Abdominal segment VIII with four postdorsal setae, IX with two of which one is longer than the other. Seta on pedal area short. Eusternum with the setae short, subequal. Sternellum present. Asperities generally distributed over whole body, somewhat more conspicuous ventrally on abdominal segments VII, VIII and IX.

H. ulkei Horn. Barcroft, Va., November 11, 1924, ex wood furniture in old building, M. T. Van Horn. Brooklyn, N. Y., February 13, 1948, in woodwork of house, Mollie Dicker.

XV. Genus **Stenoscelis** Wollaston, 1861

(Fig. 2)

Frons with five pairs of setae. Epipharynx with the anterolateral

setae in a diagonal line, the anteromedian setae arranged transversely. Mandible with one tooth, the dorsal inner margin slightly rounded subapically, the dorsal condyle produced and having a sharp rim. Mala with seven dorsal setae, the most posterior seta distinctly out of line. Thoracic spiracle bicameral. Mesothorax and metathorax with four postdorsal setae. Sternum with one pair of moderately long setae. Abdominal spiracles unicameral. Typical abdominal segments with four dorsal folds and five postdorsal setae of which 1, 2 and 4 are short, 3 and 5 moderately long. Anus small, subdorsal, each lateral anal lobe with three setae of varying length. Proventriculus without sclerotized wall or asperities.

Head yellowish orange, not perceptibly lighter dorsally. Internal epicranial ridge present, indistinct. Frontal suture not discernible posteriorly. Endocarina present, indistinct. Ocellus indistinct. Labral sensillae in a nearly straight, transverse line or the median sensilla slightly more basal. Labral rods long, straight, subparallel or slightly convergent posteriorly. Anterior group of sensory pores on epipharynx consisting of four pores placed in front of anterior pair of median spines, the posterior group consisting of four pores. Premental sclerite interrupted but with indication of median extensions.

Pronotum with eleven setae. Spiracular area of mesothorax with two setae, one short the other short to very short. Mesothorax and metathorax with postdorsal seta 1 short to moderately long, 2 short, 3 and 4 moderately long. Pedal area with six setae.

Abdominal segment VIII with four postdorsal setae, IX with two. Seta on pedal area short to moderately long. Eusternum with the setae short, subequal. Sternellum present. Asperities somewhat more distinct ventrally on abdominal segments VIII and IX.

S. brevis (Boh.). College Heights, Md., February 1943, in dead tulip poplar, W. H. Anderson. Nicholson, Miss., January 29, 1945, in solid wood, dead tree, *Castanea pumila*. Nicholson, Miss., January 30, 1945, in dead limbs *Myrica* sp. Snow Hill, Md., December 23, 1947, in dead holly wood (scar on tree), W. H. Anderson.

S. andersoni Buch. College Heights, Md., February 7, 14 and 21, 1943, in rotting birch log, W. H. Anderson.

First-stage larvae of each of the above-listed species have been studied. They agree with the full-grown larvae in all the important characteristics. An egg tooth is present immediately above the spiracle of the first abdominal segment in both species.

XVI. Genus **Cossonus** Clairville, 1798

(Figs. 1, 15, 18)

Frons with four (*lupini*) or five pairs of setae. Labrum subtriangular, pigmented and sclerotized throughout. Median sensilla on labrum at or before the middle, the lateral sensillae slightly behind the middle, or basal (*crenatus, corticola*). Epipharynx with the anterolateral setae arranged in a nearly straight longitudinal line, one pair of anteromedian setae arranged longitudinally. Mandible with two apical teeth and large, carinate, flattened, molalike projection on dorsal inner margin. Mala with seven dorsal setae, the posterior setae in line. Peritreme of thoracic spiracle oval. Postdorsum of mesothorax and

metathorax with three (*lupini*), four or five setae, when with five (*concinnus*, *corticola* and *crenatus*) then alar area not distinguishable. Sternum with one pair of moderately long to long setae. Abdominal spiracles bicameral. Typical abdominal segments with four dorsal folds. Proventriculus without sclerotized wall or asperities.

Head scarcely if at all pigmented. Internal epicranial ridge present, indistinct. Frontal suture indistinct posteriorly. Endocarina absent or very vague. Ocellus not discernible. Labral rods moderately long, subparallel, close together. Anterior group of epipharyngeal sensory pores consisting of one pore (rarely two), placed in front of median spines, the posterior group consisting of four to six small pores, often in paired clusters. Premental sclerite developed laterally, broadly interrupted at the middle, with indication of median extensions. Posterior pair of setae on postmentum separated by a distance one-half or more than one-half as great as (but distinctly less than) that between the setae of middle pair.

Pronotum with ten (*lupini*) or eleven setae. Mesothorax and metathorax with seta 1 distinctly longer than 2. Pedal area with five (*lupini*) or six setae.

Abdominal segments I to VII with four (*lupini*) or five postdorsal setae, segment VIII with three or two, segment IX with two or one. Seta on pedal area elongate. Eusternum with the more lateral seta short to moderately long, the more ventral seta distinctly longer. Sternellum present. Anus subdorsal, small. Asperities generally distributed over the body, more conspicuous ventrally on abdominal segment VIII.

C. concinnus Boh. Whiele, Va., December 1938, from wind-thrown oak, R. L. Furniss. Greenbelt, Md., October 27, 1940, ex decaying oak log, W. H. Anderson.

C. ponderosae Van D. Klamath Falls, Oreg., July 1927, in sapwood of dead tree, F. P. Keen. Klamath Falls, Oreg., June 1928, in wood of dead tree, F. P. Keen.

C. lupini Van D. San Francisco Sand Dunes, Calif., January 28, 1934, in decaying *Lupinus arboreus*, P. C. Ting.

C. crenatus Horn. Klamath Falls, Oreg., July 11, 1927, in sapwood of dead tree, F. P. Keen.

C. corticola Say. University Park, Md., February 1945 (adults taken in the same log in June), in dead pine log, W. H. Anderson.

C. parallelepipedus (Hbst.). Orlogsvaerftet, Copenhagen, Denmark, 1934, taken with adult in old poplar, West (through J. P. Kryger).

C. cylindricus Sahl. Bought from Ed. Reitter in 1922. No data available.

XVII. Genus **Mesites** Schoenherr, 1838

The available larvae of the species of this genus are remarkably similar to those of *Cossonus*. On the basis of larval characters it would be more satisfactory to consider *Mesites* as a synonym of *Cossonus*.

In addition to the differences shown in the key, there is one additional minor difference. The median extensions of the postmental sclerite are more distinct on the larvae of *Mesites* than on those of *Cossonus*.

Mesites sp., probably *cunipes* Boh. Italy, August 21, 1947, in wood of *Populus*, intercepted in quarantine at New York City.

Mesites sp. Mayo Beach, Mayo, Md., August 30, 1944, in log lodged in sand on beach, W. H. Anderson.

XVIII. Genus **Nyssonotus** Casey, 1892

Frons with five pairs of setae. Clypeal seta 1 short, 2 very short. Labrum broader than long, not subtriangular, the anterior margin rounded. Epipharynx with the anterolateral setae arranged in an oblique row, the anteromedian setae arranged transversely. Mandible with a subapical tooth and a short, inconspicuous projection on dorsal inner margin. Mala with six dorsal setae. Peritreme of thoracic spiracle subcircular. Mesothorax and metathorax with four postdorsal setae of which 1, 3 and 4 are short to moderately long, subequal, 2 short. Sternum with one pair of short to moderately long setae. Abdominal spiracles bicameral. Typical abdominal segments with four dorsal folds and five postdorsal setae of which 1, 3 and 5 are short to moderately long, 2 and 4 short. Eusternum with the setae short to moderately long, subequal. Proventriculus without sclerotized wall or asperities.

Head orange, with a broad, dorsal nonpigmented stripe. Internal epicranial ridge absent. Frontal suture indistinguishable posteriorly. Endocarina distinct, nearly one-half as long as frons. Ocellus large, moderately distinct. Labral sensillae in a nearly straight transverse line near base of labrum. Labral rods short, straight, slightly convergent posteriorly. Anterior group of sensory pores on epipharynx consisting of two pores, placed in front of median spines, the posterior group consisting of four pores. Setae on outer surface of mandible not close together at bases. Premental sclerite scarcely pigmented, with anterior and posterior median extensions. Posterior pair of setae on postmentum separated by a distance slightly greater than that between the setae of middle pair.

Pronotum with eleven setae. Pedal area with six setae.

Abdominal segment VIII with four postdorsal setae, IX with two, both long. Seta on pedal area short to moderately long. Sternellum present. Anus slightly above the middle of posterior end of body, each lateral anal lobe with three minute setae. Asperities sparse, restricted in distribution.

N. seriatus Csy. Fish Creek, Ariz., December 14, 1913, in *Yucca*, H. S. Barber. Menard, Tex., April 15, 1946, in old stalk of *Yucca*, L. J. Bottimer.

XIX. Genus **Catolethrus** Schoenherr, 1838

Frons with five pairs of setae. Clypeal seta 1 very short, 2 short. Epipharynx with the anterolateral and anteromedian setae arranged transversely. Mandible with two apical teeth, the dorsal inner margin with two triangular projections but molar area not discernible. Mala with seven dorsal setae, the two posterior setae of the row more slender than the anterior setae and distinctly out of line. Mesothorax and metathorax with four postdorsal setae. Sternum with one pair of moderately long to long setae. Abdominal spiracles bicameral. Typical abdominal segments with five dorsal folds and with five post-

dorsal setae of which 1, 3 and 5 are long, 2 and 4 short to very short. Anus terminal, not subdorsal, surrounded by eight lobes, each lateral lobe with two moderately long setae, the ventral lobe with a pair of short setae. Proventriculus with weakly sclerotized walls and simple, acutely pointed asperities.

Head orange, with paired, narrow, posteriorly convergent non-pigmented stripes dorsally. Internal epicranial ridge moderately distinct. Frontal suture distinct throughout its length. Endocarina absent. Ocellus moderately distinct. Sensillae on labrum basal, the median sensilla slightly in front of the other two. Labral rods moderately long, nearly straight, subparallel, rather widely separated. Anterior group of sensory pores on epipharynx consisting of four pores, in front of the median spines, the posterior group consisting of four pores. Premental sclerite with short anterior and long, slender, posterior median extensions. Posterior pair of setae on postmentum separated by a distance subequal to that between the setae of middle pair.

Pronotum with eleven setae. Mesothorax and metathorax with postdorsal setae 1, 3 and 4 long, 2 short. Pedal area with six setae.

Abdominal segment VIII with four postdorsal setae, IX with two, both of which are long. Seta on pedal area long. Eusternum with the more lateral seta short, the more ventral seta long. Sternellum present. Asperities apparently absent ventrally, except on abdominal segments VIII and IX, moderately abundant dorsally.

C. nasalis Boh. Sao Paulo, Brazil, in dry corn stalks, H. L. Parker.

XX. Genus **Rhyncolus** Germar, 1817

Frons with four pairs of setae. Epipharynx with the anterolateral and anteromedian setae arranged transversely. Mandible with two apical teeth and short, small projection on dorsal inner margin. Mala with six dorsal setae, the most posterior seta obviously more slender than the more anterior setae and distinctly out of line. Mesothorax and metathorax with four postdorsal setae. Sternum with one pair of short to moderately long setae. Abdominal spiracles bicameral. Typical abdominal segments with four or five dorsal folds and five postdorsal setae of which 1, 3 and 5 are moderately long to long, 2 and 4 short. Anus slightly subdorsal, each lateral anal lobe with three setae, one short, two moderately long. Postdorsum of metathorax and typical abdominal segments with numerous fine asperities around and between the setae. Proventriculus with sclerotized wall and distinct asperities.

Head orange to brownish yellow, lighter dorsally. Internal epicranial ridge absent or developed for a short distance posteriorly. Frontal suture indistinct posteriorly. Endocarina absent. Ocellus indistinct. Labral sensilla basal. Labral rods moderately long, close together, subparallel or slightly convergent posteriorly. Anterior group of sensory pores on epipharynx consisting of four pores, in front of anterior pair of median spines, the posterior group consisting of four pores. Premental sclerite complete, somewhat lighter or interrupted (*R. brunneus*) in the middle. Posterior pair of setae on postmentum separated by a distance somewhat greater than that between the setae of middle pair.

Pronotum with eleven setae. Spiracular area of mesothorax with two or three setae of which one is short to moderately long, the remainder short. Mesothorax and metathorax with postdorsal setae 1, 3 and 4 moderately long to long, 2 short to moderately long. Pedal area with six setae.

Abdominal segment VIII with four or five postdorsal setae, IX with two, of which one or both are long. Seta on pedal area short to moderately long. Eusternum with the more lateral seta short, the more ventral seta slightly but distinctly longer. Sternellum present. Asperities generally distributed over whole body except laterally.

Rhyncolus sp., probably *oregonensis* Horn. Klamath Falls, Oreg., July 11, 1927, in sapwood of dead tree, F. P. Keen.

R. pallens Csy. Bodega Bay, Sonoma County, Calif., January 14, 1948, *Lupinus albifrons*, T. O. Thatcher.

R. discors Csy. University Park, Md., March 28, 1943, in dead pine, W. H. Anderson. (First-stage larvae of this species were studied. Pointed egg teeth are present on abdominal segments I to VIII immediately above and behind the spiracle.)

R. brunneus Mann. Terrace, British Columbia, Canada, 1940, from hemlock, (Mrs.) M. E. Clark.

"Rhyncolus protractus Horn." 1873. This species was transferred to *Macrorhyncolus* Wollaston, 1873, by LeConte in 1876. In spite of the fact that Champion (1910) stated that it was misplaced in the genus *Macrorhyncolus*, Leng (1920) catalogued it under that name and it stands there in North American literature. After studying the larva of this species and comparing it with the brief remarks and drawings of *M. ventilaginus* Mshll. by Gardner (1938) it is obvious that Champion is correct and that *Macrorhyncholus* should be dropped from North American lists.

The problem arises immediately as to the proper generic name under which *protractus* should be listed. It shows strong affinities with *Stenancylus colomboi* Csy., according to Champion (1910), and possibly should be placed in the genus *Stenancylus*. Unfortunately we do not have larvae of *colomboi* so comparisons with that species cannot be made. However, there is no doubt that the larva of *protractus* bears a considerable resemblance to those of *Rhyncolus* and it must be transferred to a genus near the latter, if not to *Rhyncolus* itself. Since the only difference found so far between the larva of *protractus* and those placed in *Rhyncolus* is in the distribution of the asperities around and between the postdorsal setae on the metathorax and the typical abdominal segments, I have replaced *protractus* in *Rhyncolus*, the original combination.

XXI. Genus **Phloeophagus** Schoenherr, 1838

I am unable to find any means of separating larvae of the species placed under this generic name from the larvae of the species placed under *Rhyncolus*. From the standpoint of the larvae, therefore, *Phloeophagus* should fall as a synonym of *Rhyncolus*.

P. minor Horn. University Park, Md., February 28, 1943, in hard, dead wood (maple?), W. H. Anderson. University Park, Md., January 28, 1945, in hard, dead scar wood on trunk of tulip poplar (in association with *Pentarthrinus* sp., poss. *nitens* (Horn)), W. H. Ander-

son. (First-stage larvae of this species have an egg tooth above each spiracle on abdominal segments I to V, inclusive.)

P. californicus Van D. San Diego, Calif., January 1, 1944, in dead pepper wood.

P. lignarius (Marsh.). Dyrehaven, Denmark, November 23, 1937, *Fagus*, J. P. Kryger. Holte, Denmark, April 7, 1935, in elm wood, J. P. Kryger.

P. turbatus Boh. Dyrehaven, Denmark, September 23, 1939, in *Fagus*, J. P. Kryger.

In his original description of *Phloeophagus*, Schoenherr includes as type: "*Phloeophagus lignarius*." This has been interpreted by Marshall (1937) to be (*Cossonus lignarius* Gyll., 1813) = *Phloeophagus turbatus* Boh., 1838, not *Curculio lignarius* Marsham, 1802. Since *turbatus* Boh. and *lignarius* Marsh. appear to be congeneric both should stand under *Phloeophagus* Schoenherr. Hence my inclusion of the two European species under this generic name.

XXII. Genus **Macrancylus** LeConte, 1876

Frons with four pairs of setae. Epipharynx with the anterolateral and anteromedian setae arranged transversely. Mandible with two apical teeth, without flattened projection on dorsal inner margin. Outer surface of mandible with rounded tubercle just dorsal to mandibular setae. Mala with seven dorsal setae, the posterior setae in a smoothly curved row. Mesothorax and metathorax with four postdorsal setae of which 1, 3 and 4 are long, 2 short. Sternum with one pair of long setae. Abdominal spiracles bicameral. Typical abdominal segments with three dorsal folds and with five postdorsal setae of which 1, 3 and 5 are long, 2 and 4 short to very short. Abdominal segment VIII with three postdorsal setae, IX with two. Proventriculus without sclerotized wall or asperities.

Internal epicranial ridge present. Ocellus indistinct. Labral sensillae basal, the median sensilla slightly more anterior. Anterior group of sensory pores on epipharynx consisting of four pores, placed in front of median spines, the posterior group consisting of four pores. Premental sclerite evidently not pigmented. Posterior pair of setae on postmentum separated by a distance greater than that between the setae of middle pair.

Pronotum apparently with eleven setae. Pedal area with six setae.

Seta on pedal area of abdominal segments moderately long. Eusternum with the setae short to moderately long, subequal. Sternellum present. Anus terminal, evidently not subdorsal [the specimens are too poor to warrant any statement regarding the setae on anal lobes]. Asperities only slightly more distinct ventrally on abdominal segments VIII and IX.

M. linearis Lec. Indian River, Fla., April 1880, in drift wood on sea beach, Hubbard No. 176.

The two larvae of this species in the collection are in poor condition. It should be noted also that there was doubt in Hubbard's mind that the association with the adults was definite.

XXIII. Genus **Caulophilus** Wollaston, 1854

Frons with four pairs of setae. Labral rods nearly straight, slightly convergent posteriorly. Epipharynx with the anterolateral setae at the apices of a triangle, the innermost seta being slightly posterior, the anteromedian setae arranged transversely in a single line following curve of median part of anterior margin of labrum. Anterior group of sensory pores on epipharynx consisting of two pores, placed between the anterior and posterior pairs of median spines. Mandible with two apical teeth and a rounded projection near the middle of dorsal inner margin, the inner surface of the projection granular. Mala with six dorsal setae, the most posterior seta out of line with the anterior setae. Mesothorax and metathorax with four postdorsal setae of which seta 1 is short, usually slightly longer than 2, setae 3 and 4 moderately long. Sternum with one pair of short to moderately long setae. Abdominal spiracles bicameral. Typical abdominal segments with three dorsal folds and with five postdorsal setae of which seta 1 is short to moderately long, 3 and 5 moderately long, 2 and 4 short. Abdominal segment VIII with five postdorsal setae, IX with three of which two are subequal, distinctly longer than the third. Eusternum with the setae short, subequal. Proventriculus without sclerotized wall or asperities.

Head orange. Internal epicranial ridge absent. Frontal suture distinct throughout its length. Endocarina distinct, one-half as long as frons. Ocellus small but distinct. Lateral sensillae on labrum near the middle, the median sensilla more nearly basal. Posterior group of sensory pores on epipharynx consisting of two clusters, two pores in each cluster. Setae on outer surface of mandible rather close together, one dorsal to the other. Premental sclerite pigmented, with anterior and long posterior median extensions. Posterior pair of setae on postmentum separated by a distance subequal to that between the setae of middle pair.

Pronotum with eleven setae. Pedal area usually with seven setae. Seta on pedal area of abdominal segments short. Sternellum not discernible. Anus terminal, not subdorsal. Asperities generally distributed over whole body.

C. latinasus (Say). Several lots of material have been studied. All of them are from the seeds of avocado (*Persea*) and are from the following localities: Florida (Homestead and Coconut Grove), Guatemala and Lower California.

XXIV. Genus **Apotrepus** Casey, 1892

(Fig. 10)

Frons with four pairs of setae. Labral rods slightly convergent posteriorly. Epipharynx with the anterolateral and anteromedian setae arranged transversely. Anterior group of sensory pores on epipharynx consisting of two pores placed between the anterior and posterior pairs of median spines. Mandible with two apical teeth and moderately prominent projection subapically on dorsal inner margin, the setae on outer surface of mandible adjacent at base. Mala with six dorsal setae the most posterior dorsal seta out of line. Mesothorax and metathorax with four postdorsal setae of which 1, 3 and 4 are long,

2 short. Sternum with one pair of long setae. Abdominal spiracles bicameral. Typical abdominal segments with three dorsal folds and with five postdorsal setae of which setae 1, 3 and 5 are long, 2 and 4 short. Abdominal segment VIII with four postdorsal setae, segment IX with three. Eusternum with setae short to moderately long, subequal. Proventriculus without sclerotized wall or asperities.

Head orange, lighter dorsally. Internal epicranial ridge present. Frontal suture distinguishable throughout its length. Endocarina vague, approximately one-third as long as frons. Ocellus moderately distinct. Labral sensillae basal, in a nearly straight, transverse line. Posterior group of sensory pores on epipharynx consisting of four scattered pores. Premental sclerite lightly pigmented. Posterior pair of setae on postmentum separated by a distance greater than that between the setae of middle pair.

Pronotum with eleven setae. Pedal area with seven setae.

Seta on pedal area of abdominal segments moderately long. Sternellum present. Anus terminal, evidently not subdorsal. Asperities generally distributed over whole body.

A. densicollis Csy. Tucson, Ariz., in *Cereus*, U. S. D. A. No. 758. (The three larvae studied are in poor condition.)

XXV. Genus **Dynatopechus** Marshall, 1931

(Fig. 9)

Frons with four pairs of setae. Labrum subtrapezoidal, not pigmented. Epipharynx with the anterolateral setae arranged in a subtransverse row. Mandible with two apical teeth, without molar area, the setae on outer surface widely separated at base, one behind the other. Mala with six dorsal setae, the most posterior dorsal setae only slightly out of line. Postdorsum of mesothorax and metathorax with four setae. Sternum with one pair of moderately long setae. Abdominal spiracles bicameral. Typical abdominal segments with three or four dorsal folds. Proventriculus without sclerotized wall or asperities.

Head orange brown, with two narrow but distinct dorsal epicranial non-pigmented stripes which converge posteriorly. Internal epicranial ridge moderately distinct. Frontal suture distinct throughout its length, angulate posteriorly. Endocarina present, slightly less than one-half as long as frons. Setae on frons short to moderately long, subequal. Ocellus present, small. Sensillae on labrum basal. Labral rods moderately long, stout, subparallel. Anteromedian setae on epipharynx arranged transversely. Anterior group of epipharyngeal sensory pores consisting of four pores, placed in front of the median spines, the posterior group consisting of four pores in a compact cluster. Premental sclerite with broad posterior median extension. Posterior pair of setae on postmentum separated by a distance subequal to that between the setae of middle pair.

Pronotum with eleven setae of which ten are moderately long to long, subequal. Mesothorax and metathorax with postdorsal setae 1, 3 and 4 long, 2 short. Alar area distinguishable. Pedal area with six setae.

Abdominal segments I to VII with five postdorsal setae, VIII with four, IX with two. Typical abdominal segments with postdorsal setae

1, 3 and 5 long, 2 and 4 short. Seta on pedal area short to moderately long. Eusternum with the more lateral seta short to very short, the more ventral seta moderately long. Sternellum absent. Anus terminal, not subdorsal. Asperities inconspicuous, short, and sparse to moderately abundant.

D. calandrodes Zimm. Honolulu, T. H., October 1948, from lima beans, E. C. Zimmerman.

Dynatopechus sp. Honolulu, T. H., April 7, 1941, in leis containing seeds of *Canavalia* sp.

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ERRATUM AND NOTE

Mr. Borys Malkin informs me that the correct type locality for *Meristomeringina mimetes* (Ann. Ent. Soc. Amer., 45: 39) is Bertoua, not Bertona, as given in the original description and as it appears in the labels. Mr. Malkin writes: "I obtained these specimens by emptying the contents of the bulbous lamps in the local hotel."—M. T. J.

In the membership list, page 156 of the current volume, J. D. Hood should have been listed as a fellow of the Society.

THE LINNEAN AND DEGEERIAN SPECIES OF AMERICAN TABANIDAE

(Diptera)

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Eight names for tabanids from the Americas were offered by the venerated Swedish naturalist, Carl von Linné (Linnaeus), and his contemporary, Carl DeGeer, both of whom died in the same year, 1778, though the former was the elder by 14 years. All were ascribed to *Tabanus*, although DeGeer's *variegatus* has since been recognized as a common but variable Neotropical *Chrysops*.

Of the remaining seven, only *Tabanus mexicanus* L. and *T. giganteus* DeG. have been generally accepted as recognizable, while the name, *T. occidentalis* L., has been used, but recently has been cast in doubt as the complexity of the group has become better recognized (see Fairchild 1942).

Since Linné drew upon the DeGeer collection for some of his descriptions, and since all might be prior names for American species, as most of the original descriptions were too brief for enlightenment, it seemed desirable to try to settle the identity of such others of these names as was possible by inquiry and study of any existing types.

There are no American specimens of *Tabanus* in the Linnean collection in London. Nor is much, if any, help afforded by reference to the collections and reports of Fabricius and his reviewer Wiedemann. It is most unfortunate that the thorough early monographer of the family in the New World, Baron C. R. von Osten Sacken, did not make a search for authentic material of these species during his visit to some of the European museums in 1859.

Through correspondence with Drs. René Malaise and Felix Bryk, and the generous loan of the few existing specimens in the Ricksmuseum of Natural History in Stockholm, the writer has been enabled to add a little light on the identity of these early names.

Tabanus mexicanus Linné

Though the refined genus *Chlorotabanus* now contains four recognized species, the one to which *mexicanus* L. (and its supposed synonym *olivaceus* DeG.) has been applied fortunately agrees with the type of the latter, and this also is almost certainly the type of Linné's species as confirmed by Bryk. As Bryk has pointed out, taxonomic practice then was far different from now, and Linné himself was known to have changed capriciously a few on his own species names in later publications. It is perhaps not surprising that DeGeer has also offered what

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he apparently considered more appropriate names for specimens in his own collection which previously had been named by Linné.

The type is 12 mm., yellowish brown, undoubtedly due to age, and is intact except for missing third antennal segments. The only labels are "Tabanus olivaceus DeGeer" and "(mexicanus L.)." Structurally, it is in close agreement with better preserved greenish yellow specimens I have from "Cayenne," Canal Zone and Costa Rica.

Tabanus calens Linné

The identity of this has long been in doubt and Osten Sacken (1876) has stated that it "is *not giganteus* DeGeer" though DeGeer himself has indicated they are the same, apparently paralleling the situation suggested above for *mexicanus*. The confusion has been heightened by the difference in the two original though brief descriptions, and the writer was privileged to study two early Neotropical specimens labelled *calens* by Wiedemann through courtesy of Dr. Fritz Peus, of the Berlin Museum, which agree with DeGeer's description though not with his later examined type. Wiedemann probably never had an opportunity to study DeGeer's collection. These represent some Neotropical species unrecognized by me, though they resemble *Macrocormus* without wing spurs.

Stone (1938) justifiably believed that *calens* was "quite probably one of the *lineola* group" and it is difficult to understand how Linné could have based his lined abdomen on the DeGeer type of *T. giganteus*. Nevertheless, Bryk has indicated his belief through long familiarity with Linneana, that through some carelessness, or mixup in notes during a visit to DeGeer (and as customarily, without the aid of a glass) he may have considered the bloom on the abdomen to indicate the original presence of lines. Bryk further states "I am quite convinced that our specimen which you examined is the type of *calens*. DeGeer would have been intelligent enough never to identify his *giganteus* with Linné's *calens* if he hadn't known that his *giganteus* was the model for *calens*" (translation).

Under these circumstances, and after concurrence by both Drs. Stone and Bequaert who examined the facts and correspondence, the writer concludes that *giganteus* is a synonym of *calens*.

The type is in fair condition, though the third antennal segments are missing, and the abdomen somewhat rubbed. The integument above and below has redder shades than the average *giganteus*, and with the usual pale-haired median triangles suggested only on tergite 1 of the type. There is no locality label as is customary with DeGeer specimens, but it carries the later label "T. giganteus, T. calens."

There does not appear in the DeGeer collection any other specimen with a more obviously lined abdomen which Linné could have seen, though there is a specimen labelled *Tabanus occidentalis* which Bryk doubts is Linné's type, since Linné acknowledged the source of the original from his student Loefling in the description, as DeGeer would have done later (1776, p. 228) if this had been the type.

The prior name for the familiar North American *T. giganteus* DeGeer thus becomes *T. calens* Linn. and disposes of another controversial name.

Tabanus fervens Linné

There is in the DeGeer collection a headless specimen otherwise in fair condition which on examination as pointed out by Dr. Bequaert agrees in wing and body characters with *Phaeotabanus semiflavus* Krober. I have a specimen from Para, Brazil, which agrees closely, though the indefinite sub-stigmal dark band of the wings is a little narrower, leaving the base of the discal cell and all of the second basal cell less densely fumose than in the type. The DeGeer specimen is labelled "Tabanus fervens DeGeer," and according to Bryk, is probably, though not surely, the Linnean type because of questions in printed acknowledgment of the source.

In the writer's estimation the synonymy of *semiflavus* appears warranted after evaluation of this information.

Tabanus exaestuans Linné

In the DeGeer collection there are two specimens, one with abdominal rings collapsed by pests, labelled "*Tabanus exaestuans* DeGeer." Though both are obviously somewhat faded with age, they are unquestionably the same as the well-known *Leucotabanus leucaspis* (Wied.). The appendages, including antennae, are intact. Both wings of one, and one of the other, have short spurs at the bases of veins R_4. The smaller, undamaged specimen of the two, is 11 mm.

These are also probably, though not certainly, the types of Linné. Synonymy of the two names seems acceptable.

Tabanus nebulosus DeGeer

The type is quickly recognizable as what we are calling *T. ferrifer* Wlk. (syn. *T. druyvesteijni* Szil.). It is dorsally worn and the thorax damaged by pests, but the three rows of abdominal spots and the prescutellar black patch are plain and all the appendages are intact except that the annuli of one antenna and the entire third segment of the other are missing. The thorax and face are a little darkened by greasing. The hind tibial fringe is entirely red. The palpi are robust basally, attenuated apically, about half the length of the proboscis. These and the front are as in compared specimens from several Neotropical localities.

As usual there is no locality label on the type though it is reported to be from Surinam. The identity of another early, queried name is thus established.

Chrysops variegata (DeGeer)

This common Neotropical species as now known is one of the most variable in the Western Hemisphere and the synonymy including varieties is extensive. Krober (1925, 1934) placed it in his subgenus *Heterochrysops* because of the hyaline discal cell, and he recognized three varieties, *subfacipennis* Macq., *peruviensis* Krb., and *venezuelensis* Krb., to which Pechuman (1937) added a fourth, *lynchii* Brethes. Fortunately, the type is in an unusually good state of preservation considering its age. All of the appendages, including antennae, are intact, except that the left middle leg and the right hind tarsi are missing. A dermestid larva has obviously eviscerated the body without

damage to the exterior, although on emergence through a small hole near the neck, the latter was almost severed. The head is at present, therefore, insecurely attached to the thorax. Bequaert (1940) discussed the synonymy and the reasons for his considering Krober's varieties as worthless.

Considering the abundance and wide distribution of this Neotropical pest and its variability, it appears desirable to redescribe the type, presumably from Surinam (though not so labelled), which appears to be intermediate between Krober's (1925) typical "*costatus* F." and "var. *venezuelensis*," Krb.

Female, 8.5 mm. The usual characters of *variegata* DeG. (syn. *costata* Fabr.) with the following features: Occipital and frontal calli brown, face and cheeks principally brown with reduced yellowish shadows; thorax with complete yellow and brown stripes, scutellum yellow with an indefinite brown disc. Abdomen yellow with the characteristic blackish pattern barely encroaching submedially on the front margin of tergite 4, the sublateral lines faintly produced onto tergite 6, tergite 7 with two broad black sublateral spots, tergite 8 and extended cerci yellow; venter yellow darker caudally on sternite 7, and laterally on 3. Wing picture dark brown in the usual pattern—first basal cell infuscated in about the basal half, outward extension indefinite with an unusual shadow along the discal ridge to the apex; second in about the basal fourth; discal and cubital cells about two-thirds or more hyaline; outer margin of crossband almost straight with slight convexity on vein M; subapical, hyaline spot broad above, narrowed behind to hind margin and continuous, forming an inverted, complete narrow triangle.

APPENDED SYNONYMIC NOTES ON NEOTROPICAL SPECIES

The Neotropical tabanid fauna is complex and many early names have been proposed without subsequent recognition while new names are appearing rather rapidly. Without waiting, therefore, for a more appropriate place to publish accumulating synonymy for benefit of clarification, the following miscellaneous observations are recorded, in part, as unpublished conclusions of the late Professor Hine incidental to a study of types in the British Museum.

Tabanus bifenestratus Osten Sacken

This Neotropical species has not been identified since original description of the unique, somewhat damaged type from Durango, Mexico. It is with regret that it is now evident, as called to my attention by Fairchild, that the striking *T. bequaerti* Philip (J.N.Y. Ent. Soc., 51: 114, 1943) from El Salto Diego, Mexico, is a synonym. The difference of one revived eye stripe in description of the former instead of two does not offset the similarity of the other unusual characters. The allotype male of *T. bequaerti* thus becomes the neallotype of *T. bifenestratus*.

Other synonymy includes the following: *Tabanus jilamensis* Hine (1925, Honduras) equals *T. unipunctatus* Bigot (1892, Amer. Merid.); *T. mordax* Hine (1920, Bolivia, not Austen, 1912) equals *T. tacitus* Hine (1920, Uruguay); *T. fuscicrura* Bigot (1892, Mexico) equals

T. subruber Bell. (1859, Mexico); *T. nuntius* Wlk. (1854, Brazil) equals *T. obsoletus* Wied. (1821, Brazil); *T. griseopleuris* Krb. (1931, Costa Rica) equals *T. quinquevittatus* Hine (1925, Guatemala; n.n. for *quinquemaculatus* Hine, 1907, not 1904 lapsus); and *T. schmidti* Krb. (1931, Costa Rica) equals *T. pruinosus* Bigot (1892, Mexico).

SUMMARY

Through study of types in the DeGeer collection in Stockholm, the following new synonymy of American Tabanidae has been determined: *Tabanus giganteus* DeGeer equals *T. calens* Linné, *Phaeotabanus semiflavus* Krober equals *Tabanus fervens* Linné, *Leucotabanus leucaspis* (Wied.) equals *L. exaestuans* (Linné), *Tabanus ferrifer* Walk. equals *T. nebulosus* DeGeer. Modern identifications of *Chlorotabanus mexicanus* (Linné) (syn. *T. olivaceus* DeGeer) and *Chrysops variegata* (DeGeer) have been correct; in consideration of wide variation in the latter species as now recognized, the type is redescribed. *Tabanus occidentalis* Linné remains unrecognizable, as the type is presumably lost. Synonymic notes on seven other Neotropical species of *Tabanus* are appended.

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A CONTRIBUTION TO THE BIOLOGY OF THE SUBFAMILY CYMINAE

(Heteroptera: Lygaeidae)

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The subfamily Cyminae is recognized as being divisible into two tribes, the Kleidocerini and the Cymini. This paper presents information on the habits and immature stages of members of five genera of the subfamily.

A study of nymphal material indicates that the subfamily as constituted at present is not a natural assemblage of genera and species. Nymphs of the Kleidocerini, as represented by the type genus *Kleidocerys*, are unique among the Lygaeidae outside the subfamily Rhyparochrominae in possessing three abdominal scent gland openings. All of the species examined belonging to the Cymini, on the other hand, possess the conventional two scent gland openings. Kirkaldy, (1908), Usinger (1938), Gulde (1901) and others have pointed out the fundamental importance of the nymphal scent gland openings as taxonomic and phylogenetic characters in the Hemiptera. The difference in the number of these openings indicates that these two groups may actually not belong in the same subfamily. On the basis of present evidence the genus *Kleidocerys* appears to belong in the subfamily Rhyparochrominae. However, until nymphal stages of some of the exotic genera of the Kleidocerini become available for study it is probably premature to attempt taxonomic rearrangement at this time.

Representatives of five genera, *Kleidocerys*, *Cymus*, *Arphnus*, *Pseudocymus* and *Nesocymus* are discussed in the present paper. Keys and characterizations are referable only to the species discussed, although it is hoped they will have a wider application.

Tribe **Kleidocerini**

Kleidocerys resedae (Panz.) 1797

The principal food plant of this species appears to be birch. Observers in many localities record it from species of *Betula*. In the United States *resedae* has been reported from the following plants: Steeple bush (Torre Bueno 1924), *Dasiptemon pedicularia* and *Spiraea salicifolia* (Torre Bueno 1925), *Spirea van-houttei* (Blatchley 1926), *Arbutus*, *Typha latifolia* and *Typha angustifolia* (Claassen 1922). Butler (1923) summarized the data on European food plants of this species.

Jordan (1933) who studied the bionomics of *resedae* in Germany found the eggs deposited singly in dried birch catkins. He noted that development was very erratic, eggs and nymphs of all instars being

associated on the same catkins, indicating that egg laying may take place over a considerable period of time. He believed that only a single generation is completed annually with possibly a partial second. As Jordan found a fifth instar nymph required 19 days to attain the adult condition he assumed a three month period for complete nymphal development. Actually, the nymphal period is probably somewhat less than this as the fifth instar in many Hemiptera is of somewhat longer duration than the preceding instars.

Both Jordan and Claassen found a preference for the completely dried seeds of birch and cattails respectively, but state that the insects are able to nourish themselves equally well upon the succulent green tissues of the host plant.

Copulation takes place in the normal "reversed" position in contrast to *Cymus angustatus* where both sexes face in the same direction during the copulatory process. Further information as to the copulatory position in the Cyminae is very desirable since *Cymus angustatus* presents such a striking exception to the condition found in all other lygaeid species whose method of copulation is known to me.

K. resedae overwinters as an adult, the insects often leaving deciduous for evergreen trees (Butler 1923, Reuter 1908), but may remain in fruit catkins and fallen leaves of birch (Jordan 1933).

Immature stages

This wide ranging species forms a distinct exception to the great majority of our Lygaeidae in that its immature stages have been the subject of descriptions by three different authors. The nymphs of all instars and the egg were first described by Claassen in 1922. Butler (1923) considered the egg unknown and redescribed the fourth instar nymph. Jordan (1933) redescribed the egg and all the nymphal stages.

Tribe **Cymini**

It is inadvisable to characterize the tribe and the various genera on the basis of nymphal characters until representatives of more of the exotic genera are known. The key to genera is based upon the following species, *Pseudocymus giffardi* V. D., *Arphnus profectus* V. D., *Nesocymus calvus* (White), *Cymus angustatus* Stal, *C. discors* Horv., *C. luridus* Stal, *C. robustus* Barber and *C. glandicolor* Hahn.

GENERIC KEY TO FIFTH INSTAR NYMPHS

1. First antennal segment considerably exceeding apex of tylus; length of second antennal segment greater than length of pronotum 2
   First antennal segment not reaching apex of tylus; length of pronotum greater than that of second antennal segment 3
2. Third antennal segment twice length of first; juga produced forward as sharp spine-like projections ..... **Nesocymus**
   First and third antennal segments subequal in length; juga not produced forward as sharp spine-like projections ..... **Pseudocymus**
3. Length of head from apex of tylus to juncture of epicranial arms greater than width of pronotum at apex; distance from apex of tylus to apex of juga greater than that from apex to base of juga ..... **Arphnus**
   Length of head from apex of tylus to juncture of epicranial arms less than, or subequal to, width of pronotum at apex; distance from apex of tylus to apex of juga less than that from apex to base of juga ..... **Cymus**

Genus **Cymus** Hahn, 1831

This genus is represented in America north of Mexico by seven species. Of these nymphs of four species, *angustatus*, *discors*, *luridus* and *robustus* have been available for study. The other species, *virescens*, *bellus* and *guatemalanus* are southern in distribution and no nymphal material has been available, nor have the immature stages of these species been described.

The species of *Cymus* are phytophagous upon various species of *Carex*, *Scirpus* and *Juncus*. There are indications of differences in habitat and host plant preferences, and a study of the ecological and host relationships offers an interesting field for investigation both from the standpoint of ecological and geographic distribution and from that of species relationship.

Certain adult characters can with caution be used to separate the nymphs, but the proportions are often so much at variance in the nymphs that determinations made in this manner must be of a tentative nature. The most useful characters found in the nymphs for species separation have been the lengths of the antennal segments, both in relation to one another and to the proportions of other body parts, particularly of the pronotum.

The various instars of a given species may be separated from one another by the relative development of the mesothoracic wing pads as indicated by Slater (1943) and (1951).

The nymphs of all of the species studied show a strong "mimetic" resemblance to the seeds of the plants upon which they feed.

SPECIFIC KEY TO FIFTH INSTAR NYMPHS

1. Third antennal segment longer than second ..... **angustatus**
   Second and third antennal segments subequal, or second segment longer than third 2
2. Third antennal segment as long as or longer than fourth 3
   Fourth antennal segment longer than third 4
3. Length of third antennal segment one-third or more the width of pronotum at base ..... **luridus**
   Length of third antennal segment considerably less than one-third width of pronotum at base ..... **robustus**
4. All antennal segments concolorous, dark brown; species larger, length 4 or more mm. (Palearctic) ..... **glandicolor**
   Apical antennal segment dark brown, three proximal segments testaceous; smaller 3.5 mm. or less. (Nearctic) ..... **discors**

Cymus angustatus Stal, 1874

The food plant of this common species is *Scirpus atro-virens* Muhl. and probably other species of *Scirpus* and *Carex*. It has been reported from *Chrysanthemum leucanthemum* L. (Heidemann 1899) and *Juncus nodosa* (Van Duzee 1888). The eggs are inserted singly in the fruit and flower heads with the cephalic end pointing outward. Egg laying probably continues for a considerable period as nymphs in all stages of development may be found upon the same host plant. As Van Duzee (1888) points out the nymphs show much resemblance to the seeds of *Scirpus*, being almost indistinguishable when the insects are motionless. The species probably overwinters in the adult stage as adults are found very early in the spring. However, I have thus far been unsuccessful in taking adults in hibernation. Several European species of the

genus have also been noted as adult hibernating forms, indicating that, in the northern latitudes at least, adult hibernation is probably the normal condition for most, or all, members of the genus.

The method of copulation is worthy of special note. The normal copulatory position for Lygaeidae (copulatory patterns for the great majority of species of Lygaeidae are unknown) is in what may be called the "reversed" or linear position. In this position the two sexes face in opposite directions with the genitalia in contact. In *angustatus*, however, this "reversed" position is never assumed at any time during copulation. Preliminary to mating and during intervals between actual copulation the males often may be seen riding about on the backs of the females. This has been described by Balduf (1941) as the "coupling" position for *Phymata pennsylvanica americana* Melin, because while this is part of the mating process, actual copulation does not occur in this position. The male may move to either side of the female when copulation begins and the genitalia come into contact. The male shows definite sexual excitement at this time. The antennae vibrate rapidly and rhythmically and stroke the head of the female lightly. The rostrum vibrates more slowly, is held in an almost vertical feeding position and probes irregularly at the lateral surface of the female's prothorax. The forelegs may also be used in irregular "caressing" movements. During the entire process the female remains passive except for an occasional shuddering movement at the termination of copulation. Frequently a second male will "couple" with a female which is already copulating with a first male. Copulation usually occurs several times during a single contact between the two sexes. Notes on the mating of this species taken on May 14, 1950, will perhaps be illustrative of the process.

Stems of a species of *Carex* were introduced into a vial together with three males and four females of *angustatus*. A male specimen was observed running along a stem until a female was encountered. The male immediately mounted the female, quickly turned to face the caudal end of the female abdomen, then without hesitation reversed position and twisted off to the left side and commenced copulation. The claspers were observed working like a pair of tiny mandibles, appearing to pinch or squeeze the venter of the female. No actual holding by the claspers was noted. Copulation lasted 80 seconds during which time the characteristic antennal and rostral movements as noted above were very evident. The male then assumed the coupling position. The female inserted her beak in the *Carex* stem and began feeding. Six and one-half minutes later the male again effected copulation on the left side. During the interval between the two periods of copulation the female fed three times for 110, 180 and 50 seconds and between feedings crawled actively over the food source. The male remained entirely motionless during this process. The second copulatory period lasted 50 seconds. Copulation was subsequently effected twice more, once on the right side for 45 seconds and again on the left side for 70 seconds. Following an interval of 19 and one-half minutes the male again attempted copulation on the left side, but the two insects immediately separated, the female crawling rapidly away and the male beginning to feed. During the entire process no attempt

was made by the male to assume a "reversed" position.

In view of the interesting evidence recently presented by several herpetological workers of the importance of the copulatory process in ascertaining the phylogenetic relationships of reptile groups it appears possible that the interesting variation in copulatory positions in the Hemiptera may have important taxonomic implications.

Immature Stages

The only previous mention of the immature stages of this insect is by Van Duzee (1888) who speaks of the nymphs as follows: "They are of a dull straw-color, ovate in form, compressed or somewhat lenticulate acute behind, produced and blunt before and with the connexivum expanded and very thin."

Egg (in alcohol):—Elongate, one side moderately convex the other nearly straight; anterior end truncated, posterior bluntly rounding; no noticeable chorionic cap or processes; surface smooth, shining; color whitish becoming red during embryonic development. Length 0.965 mm. Width 0.175 mm.

First instar (in alcohol):—Elongate, robust, less obovate than in succeeding instars; general color buff-yellow; head with vertex dull white; dusky gray on side of head below eyes and on thorax laterally; eyes scarlet; abdomen tawny yellow with a large irregular orange patch in the area of the abdominal scent glands; antennae concolorous with body; apex of fourth segment dusky; apex of rostrum and of apical tarsal segment dark brown to black; two pairs of small grayish spots near apex of abdomen midway between meson and lateral margin.

Head and antennae very large and prominent; epicranial stem (coronal suture) short, arms margined with white; thoracic segments uniform in size and shape; conjunctiva of tergites five and six curving abruptly from margin to meson; rostrum long and prominent, reaching caudad over first two or three abdominal sternites; apical tarsal segment over twice length of basal. Length of antennal segments I:II:III:IV. 0.07 mm.; 0.086 mm.; 0.104 mm.; 0.19 mm. Length of body 0.80 mm. Interocular space 0.17 mm.

Second Instar (in alcohol):—Similar in form and color to fifth instar; lighter; longitudinal stripes pale and less well defined; antennae and head relatively larger and more prominent; wing pads not visible. Length of antennal segments I:II:III:IV 0.09 mm.; 0.11 mm.; 0.13 mm.; 0.22 mm. Length of body 1.58 mm. Interocular space, 0.20 mm.

Third instar (in alcohol):—Similar in form and color to fifth instar; margins of pronotum more rounding, not prominently explanate; antennae a lighter brown; no black markings at cephalo-lateral angles of developing scutellum; rostrum reaching first abdominal sternite; gray-brown band on femora of later instars here a tawny brown. Length of antennal segments I:II:III:IV 0.095 mm.; 0.17 mm.; 0.19 mm.; 0.27 mm. Length of body 2.38 mm. Interocular space 0.35 mm.

Fourth instar (in alcohol):—Form and color as in fifth instar; red stripes midway between meson and lateral margin of abdominal tergites more apparent; rostrum reaching at least to metacoxae, usually to basal abdominal sternite; wing pads diverging laterad, not exceeding anterior area of second abdominal tergite; head less strongly recessed

into pronotum. Length of antennal segments I:II:III:IV 0.12 mm.; 0.19 mm.; 0.26 mm.; 0.33 mm. Length of body 2.82 mm. Interocular space 0.40 mm.

Fifth instar (in alcohol) (Fig. 2):—General coloration testaceous; lateral region of head and pronotum, mesal area of mesothoracic wing pads and irregular markings on abdomen fuscous-brown; eyes scarlet; entire surface sprinkled irregularly with numerous round whitish spots; mesal angle at base of mesothoracic wing pads, lateral portions of anterior dorsal scent gland openings, irregular broken line on thoracic pleura, apex of rostrum and apical tarsal segment black; antennal segments dark brown becoming lighter proximad; longitudinal median white line present on dorsal surface, usually broken into median spots on abdominal tergites; ventral surface with a pair of stripes lying midway between meson and lateral margin, arising anteriorly in the region of the antenniferous tubercles and running caudad through the thoracic pleura to apex of abdomen, these stripes light reddish on head and abdomen becoming fuscous to black on thorax; all femora dull brown. Form elliptical-rounded; head large, in many individuals recessed into pronotum almost to eyes; tylus and jugae produced cephalad of antenniferous tubercles, tylus much exceeding juga and bluntly pointed at apex; antennae stout, first segment slightly swollen, second and third terete, fourth fusiform; rostrum reaching caudad at least to mesocoxae, basal segment shorter than head; pronotum subquadrate, explanate on lateral margins, anterior margin concave, posterior feebly sinuate; mesothoracic wing pads large strongly curved laterad, forming maximum width of body, completely covering those of metanotum and usually reaching caudad to anterior margin of fourth abdominal tergite; abdominal sutures almost straight, that between segments three and four curving slightly cephalad from meson to lateral margin; margin of abdomen scalloped with lateral edge of each segment rounded; fore femora not swollen, shorter than hind femora and unarmed below. Length of antennal segments I:II:III:IV 0.16 mm.; 0.29 mm.; 0.33 mm.; 0.36 mm. Length of body 3.81 mm. Interocular space 0.50 mm.

Cymus discors Horvath, 1908

Torre Bueno (1922) records the food plant of this species as *Scirpus polyphyllus* Vahl. It has also been taken on *Scirpus cyperinus* L. (Blatchley 1926) and on species of *Salix* (Drake 1922). Torre Bueno (1924) took hibernating adult individuals by sifting in winter.

The fifth instar nymph of this species may be distinguished from that of *C. angustatus* by the following characters in addition to those listed in the key. The tylus is widened at the apex and very blunt. The pronotum is only narrowly explanate on the lateral margins. No black markings are present on the cephalo-lateral angle of the scutellum or at the lateral edges of the anterior dorsal scent gland openings. The entire rostrum is dark brown while in *angustatus* it is yellowish, except at the apex. A longitudinal pair of ventral stripes may be faintly present, but are never unbroken or conspicuous.

Immature stages

Fifth instar (in alcohol) (Fig. 4):—Elongate-oval, general color dull testaceous, entire surface sprinkled with prominent round pale spots,

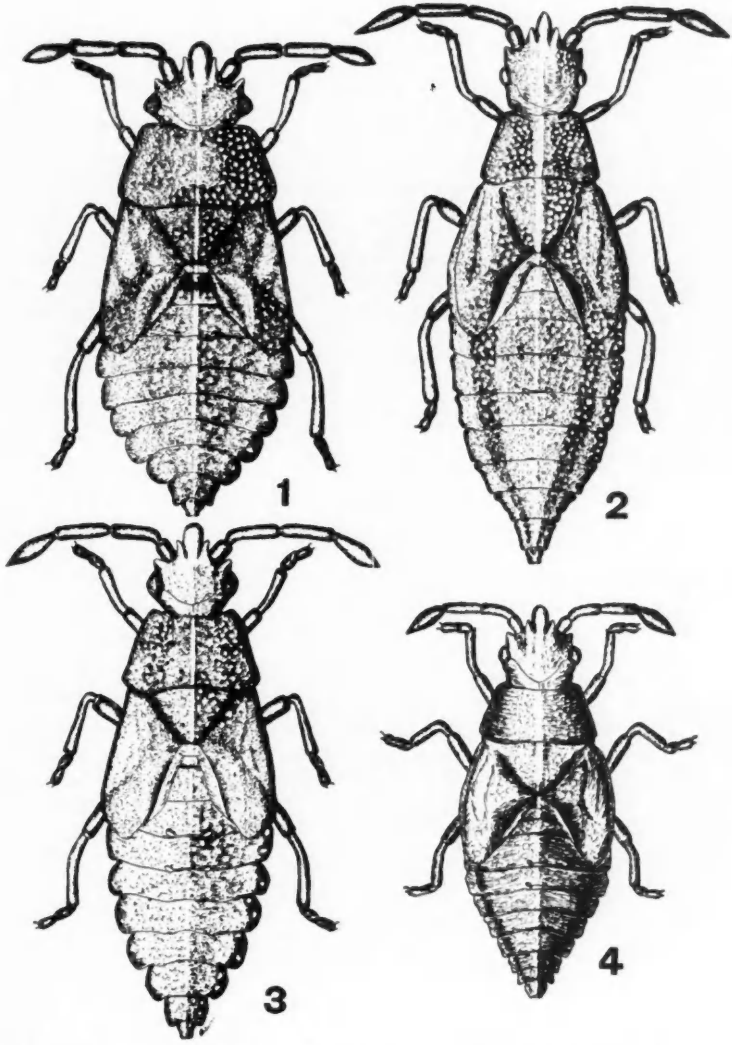

FIG. 1. *Cymus robustus* Barber. Fifth instar nymph, dorsal view. × 23.
FIG. 2. *Cymus angustatus* Stal. Fifth instar nymph, dorsal view. × 23.
FIG. 3. *Cymus luridus* Stal. Fifth instar nymph, dorsal view. × 23.
FIG. 4. *Cymus discors* Horvath. Fifth instar nymph, dorsal view. × 23.

head more dusky laterad with five or six small orange spots and a pair of larger ones midway along the epicranial arms; eyes scarlet; base of head, basal area of developing scutellum, broken, poorly defined longitudinal stripe on abdominal tergum midway between meson and margin, area about the dorsal scent gland openings, area near antero-lateral margin of abdomen and longitudinal stripes along lateral region of abdominal sternites light orange, shading to reddish; all appendages brown to fuscous; mesothoracic wing pads with three longitudinal gray-brown stripes, the apex and mesal margins similarly colored; a white median dorsal stripe running from apex of tylus to end of abdomen.

Tylus large and blunt at apex; epicranial stem short; base of head above and base of scutellar area finely and irregularly reticulated; pronotum subquadrate, posterior margin very slightly sinuate, nearly straight, lateral margins narrowly explanate, anterior margin deeply concave; mesothoracic wing pads reaching caudad to cephalic margin of fourth abdominal tergite, not divergent; rostrum not reaching metacoxae, margins of abdomen strongly scalloped as in ***angustatus***, abdomen strongly tapering caudad; apical tarsal segment less than twice length of basal. Length of antennal segments I:II:III:IV 0.16 mm.; 0.29 mm.; 0.26 mm.; 0.31 mm. Length of body 2.60 mm. Interocular space 0.43 mm.

Cymus luridus Stal, 1874

This and the succeeding species are rather closely related both structurally and ecologically. The fifth instar nymph of ***luridus*** may be readily distinguished from ***robustus*** by its relatively longer antennae and more slender pronotum. In ***luridus*** the length of the third antennal segment is never less than one-third the width of the pronotum at the base and usually considerably more than one-third the width. In ***robustus*** the length of the third antennal segment is considerably less than one-third the width of the pronotum, and in some specimens only about one-fourth the width. Furthermore, the pronotum is wider in ***robustus*** relative to its length than is the case in ***luridus***.

As one proceeds from the fifth to the earlier instars the separation of the two species becomes progressively more difficult. In the fourth instar nymph the antennal-pronotal proportions are still useable although the differences are less marked. In the first, second and third instars the differences are very minute and in the absence of reared series of both species I have hesitated to give characters for their separation at this time. The habitus of the two species in these early instars is rather marked, however. In a long series of both species taken at Belvidere, Illinois, on July 8, 1949, nymphs of ***luridus*** were straw yellow in color, the apical antennal segment usually a solid black and the abdomen tapering very strongly from the third segment to the apex. In ***robustus*** the color was a dull mottled red, the apical antennal segment usually a diffused gray on the basal one-half, and the abdomen was more robust with the third, fourth and fifth abdominal segments of nearly equal width.

Immature stages

Fourth instar (in alcohol):—Coloration similar to fifth instar, light median line more prominent; dark brown areas as in fifth instar but

more prominently marked; base of first, bases and apices of second and third, and all of fourth antennal segment dark brown to black; femora, tarsi, and rostrum dark brown, tibiae testaceous.

General form as in succeeding instar; head much more prominent, length twice that of pronotum; abdomen very strongly tapering caudad. Length pronotum 0.31 mm.; width pronotum at base 0.72 mm. Length of antennal segments I:II:III:IV 0.15 mm.; 0.27 mm.; 0.29 mm.; 0.29 mm. Length of body 2.75 mm. Interocular space 0.395 mm.

Fifth instar (in alcohol (Fig. 3):—Ground color testaceous, covered with lighter spots that presage the punctation of the adult, obscurely marked with reddish; vertex and meson of tylus lighter; lateral areas of head darker continuing as an obscure brownish stripe on pronotum and irregularly present on mesothoracic wing pads, lacking on abdominal tergites; scutellum and abdomen with a whitish central streak; first antennal segment light tan, second and third testaceous, darker at apex, apical segment dark brown; legs testaceous, tarsi dark brown, basal segment lighter on basal half; rostrum testaceous shading to dark brown at apex.

Tylus bluntly rounded at apex, extending well forward of the apices of the juga; pronotum with basal margins very narrowly explanate; length of pronotum 0.49 mm., width at base 1.06 mm.; margins of abdomen scalloped; abdomen strongly narrowed from fourth segment to apex; rostrum barely attaining the metacoxae; apical tarsal segment twice or more the length of basal segment. Length of antennal segments I:II:III:IV 0.21 mm.; 0.41 mm.; 0.41 mm.; 0.37 mm. Length of body 3.80 mm. Interocular space 0.53 mm.

Cymus robustus Barber, 1924

Immature stages

Fourth instar (in alcohol):—Very similar in form and color to fifth instar. General color slightly darker, particularly appendages; head and antennae relatively more prominent and margins of pronotum and wing pads more broadly explanate. Length pronotum 0.31 mm. Width pronotum at base 0.75 mm. Length of antennal segments I:II:III:IV 0.13 mm.; 0.21 mm.; 0.22 mm.; 0.29 mm. Length of body 2.39 mm. Interocular space 0.395 mm.

Fifth instar (in alcohol) (Fig. 1):—General coloration bright reddish-brown, much more reddish than is the related *luridus;* lateral area of head little darker than meson; longitudinal dark stripe obsolete on pronotum, usually indistinguishable on wing pads; three proximal segments of antennae testaceous, fourth dark brown on apical one-half, lighter at base; legs testaceous, apical tarsal segment dark brown, lighter at base; rostrum light fuscous becoming darker at apex.

General form less elongate than *luridus*, head and pronotum relatively broader, length of third antennal segment always less than one-third width of pronotum at base; pronotal and mesothoracic wing pad margins strongly explanate, length pronotum 0.58 mm.; width pronotum at base 1.21 mm.; abdomen less prominently tapering from fourth segment to apex and antennae relatively shorter than is the case in *luridus;* rostrum reaching between metacoxae. Length of antennal segments I:II:III:IV 0.19 mm.; 0.33 mm.; 0.34 mm.; 0.32 mm. Length of body 3.64 mm. Interocular space 0.52 mm.

Cymus glandicolor Hahn, 1831

The bionomics of this European species and descriptions of its immature stages were reported by Jordan (1935). The fifth instar nymph had previously been described by Butler (1923).

Jordan describes the copulatory process in *C. glandicolor* in a manner that suggests strongly the "coupling" rather than the copulatory position (see *Cymus angustatus* discussion). He further states that only four instars are undergone in the nymphal development, a condition that is very unusual in the lygaeids known to this writer. Dr. Jordan has kindly sent me nymphs of *glandicolor* from Germany from which material I am able to distinguish three instars that by analogy with Nearctic species, appear to be the third, fourth and fifth instars. Study of *glandicolor* is needed to clarify the relationships of the copulatory process and the number of nymphal instars between this species and those from the United States.

Genus **Arphnus** Stal, 1876

This genus is represented by three species in the Western United States. Of these an example of only one species has been available for study.

Arphnus profectus Van Duzee, 1929

Immature stages

Fifth instar (pinned):—Elongate-oval; general color testaceous, with a dark brown stripe running longitudinally midway between meson and margin from head to tip of abdomen; entire surface sprinkled with round, light yellow spots; antennae, apical tarsal segment and apical segment of rostrum dark brown to black.

Second antennal segment shorter than third, fourth fusiform; tylus blunt, very prominent and produced forward greatly beyond the apices of the juga which are acute; pronotum rugulose, with a faint transverse impression on basal third; length of pronotum 0.41 mm.; width at apex 0.53., width at base 0.85 mm.; lateral margins of pronotum and mesothoracic wing pads explanate; body across mesothoracic wing pads narrower than width of third abdominal segment; dorsal scent glands nearly equal in size, anterior slightly wider; lateral margins of abdomen scalloped; rostrum short, not reaching the mesocoxae; apical antennal segment longer than basal. Length of antennal segments I:II:III:IV 0.16 mm.; 0.24 mm.; 0.28 mm.; 0.33 mm. Length of body 3.06 mm. Interocular space 0.42 mm.

1 specimen Mt. Hermon, Calif., 4–31, E. P. Van Duzee coll. (on Juncus).

Genus **Nesocymus** Kirkaldy, 1907

This Hawaiian genus was erected to include the *Cymus calvus* of White. One nymph representing the fifth instar has been available for study.

Nesocymus calvus (White), 1881

Zimmerman (1948) reports *calvus* from *Carex*, *Cyperus*, *Eragrostis*, and *Pipturus*.

Immature stages

Fifth instar (pinned):—Elongate-oval; general color deep brown; mesal area of head and pronotum lighter; pronotal calli and lateral margin of mesothoracic wing pads near apex black; explanate lateral margins of pronotum and mesothoracic wing pads testaceous.

Antennae large, prominent and thickly beset with conspicuous hairs; head narrowing from base to apex; juga produced to sharp spine-like apices, antenniferous tubercles produced into a blunt spine laterad; pronotum subquadrate with a shallow transverse impression forming a collar near apex; length of pronotum 0.56 mm., width at apex 0.67 mm., width at base 1.02 mm.; margins of abdominal segments not scalloped; anterior dorsal scent gland opening wider than posterior; rostrum extending caudad to the mesocoxae; apical tarsal segment longer than basal. Length of antennal segments I:II:III:IV 0.26 mm.; 0.72 mm.; 0.55 mm.; 0.62 mm. Length of body 3.68 mm. Interocular space 0.56 mm.

1 specimen Nauhi Gulch, Hawaii, 5000–6000 ft. 10–2–31, Swezey & Williams coll. (on *Carex*).

Genus **Pseudocymus** Van Duzee, 1936

This is another Hawaiian genus, erected for *Pseudocymus giffardi* V. D. It was reported from *Eragrostis* by Zimmerman (1948).

Pseudocymus giffardi Van Duzee, 1936

Immature stages

Fifth instar (pinned):—General color brown, lighter mesad; antennae dark chocolate brown; legs light testaceous; eyes dull reddish.

Head large and prominent, lateral margin straight not converging from base to apex, somewhat decurved between the antenniferous tubercles; antennae extremely large, heavy and prominent, basal segment greatly exceeding apex of tylus, beset with short setae, three distal segments covered with long conspicuous hairs, third segment expanded from base to apex; pronotum subquadrate, anterior margin concave, lateral margins conspicuously explanate, length of pronotum 0.49 mm., width at apex 0.65 mm., width at base 0.92 mm.; mesothoracic wing pads broad, rugulose near apex, lateral margins explanate; abdomen short, lateral margins curving upward (may be due to shrinkage); rostrum short and weak, not reaching caudad to mesocoxae, second segment scarcely surpassing head; apical tarsal segment longer than basal. Length of antennal segments I:II:III:IV 0.35 mm.; 0.76 mm.; 0.35 mm.; 0.56 mm. Length of body 3.10 mm. Interocular space 0.56 mm.

1 specimen Nuuanu Pali, Oahu, Hawaii, 6–28–17, J. C. Bridwell coll.

ACKNOWLEDGMENTS

I wish to extend my appreciation to Dr. R. L. Usinger of the University of California for the loan of nymphs of *Arphnus*, *Pseudocymus* and *Nesocymus;* Dr. Karl Jordan of Bautzen, Germany, for specimens of *Cymus glandicolor;* Dr W. P. Hayes of the University of Illinois under whose guidance work on nymphs of the Lygaeidae was inaugurated, and Dr. H. M. Harris of Iowa State College for helpful suggestions and for making facilities available.

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PEANUT-WINGED THRIPS

(Thysanoptera: Thripidae)

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Two of the most remarkable species of thrips have been discovered recently from the American tropics. They bear wings so elaborately developed that it would have been beyond the scope of reasonable imagination for anyone to have suspected or predicted that such forms might occur in the Thysanoptera. The leading portion of the front wing is enormously ballooned, hollow, and peanut-shaped, with much of the surface heavily reticulate, fig. 4 and 5. This type of wing is unique in the thrips and consequently our definition of the order must be modified to state that thysanopteron wings are usually narrow and flat but occasionally the first pair may be extremely bulged or ballooned much in the fashion of certain Tingidae.

Of historic interest is the close relationship of these striking thrips to the extinct *Gerontothrips* Priesner, represented by an amber fossil from the Oligocene. *Arachisothrips*, the generic name here proposed for the subjects of this paper, is the second genus I have had the opportunity to describe which was phylogenetically nearest a fossil. It is an unusual coincidence that in both cases a living species of the two existing genera (*Pueblothrips* Stannard and *Arachisothrips*) came from the same location, Puebla, Mexico. *Arachisothrips* is also found in Jamaica. Similarly, both fossils concerned were from the same deposit of baltic amber.

In addition to other features, these thrips are remarkable because of their diminutive size. One male measures in total length hardly 0.5 mm. and may well have the distinction of being the smallest of the known Thysanoptera.

All of the specimens of *Arachisothrips* were collected by Collembolists, Drs. Harlow B. Mills and Federico Bonet. Spurred on by their findings, I have tried, but in vain, to recover these tiny insects from corresponding habitats. It is with pleasure, then, that I name the two species in honor of the skillful collectors who discovered them. My gratitude and appreciation is extended to these two entomologists for the gift of this material to the Illinois Natural History Survey where the types have been deposited, and to the John Simon Guggenheim Memorial Foundation under whose auspices Dr. Mills carried out investigations of the micro-insect fauna of several islands in the West Indies.

The generic name was derived from *Arachis*, the peanuts, in allusion to the shape of the wings of these thrips.

Arachisothrips gen. nov.

Minute thrips belonging to the tribe Heliothripini, with ballooned wings shaped like peanut halves, the surfaces of which are covered with

hexagonal reticulations. Apparently the species are inhabitants of ground cover in Neotropical rain forests.

Head transverse, wider than long, dorsal surface hexagonally reticulate, cheek pouch area just behind eyes convex, dorsal setae short and inconspicuous; eyes bulging; ocelli, when present, forming a small triangle located on a line bisecting the center of the eyes; antennae long and slender, about five times as long as the head, apical segments haustate, seven or eight segmented, simple sense cones on segments three to seven; mouth cones broadly rounded; maxillary palpi two segmented.

Prothorax with usual setae present but all short and inconspicuous, dorsal surface transversely striate except lateral margins which are hexagonally reticulate; pterothorax weakly reticulate except mesoscutum which tends to be longitudinally striate with striae converging at the median line; fore wings between costal margin and median vein bulged into the shape of a peanut half, bulge constricted in the middle to permit free movement of hind leg, area between median vein and posterior margin broad and flat, costal spines large and pinnate, a long seta at angle of each fore wing extending into the bulge, wing surface hexagonally reticulate; hind wings normal; legs long, all tibiae thickened at apex.

Abdomen weakly sculptured; no segment with dorsal posteromarginal setal combs.

Sexual dimorphisms:—In addition to the obvious differences of the saw-like ovipositor of the female and the genital capsule of the male several characteristics are peculiar to the sexes. Males possess two oblong medio-anterior glandular areas, one each on abdominal sternites seven and eight; females lack these areas. Males are smaller in size and lack ocelli. Females possess a double fringe of setae along the apical third of the hind margin of the fore wing; males have but a single row in this area and the setae are thicker and more spinelike. Setae of the ninth and tenth abdominal terga are long in the female but are mostly short and inconspicuous in the male.

Genotype:—***Arachisothrips millsi***, sp. nov.

Type locality:—Hardwar Gap, Portland Parish, Jamaica.

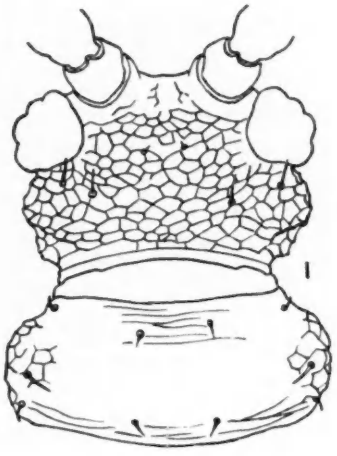
Were it not for the peculiarly shaped wings, this genus would resemble in many ways several genera in the Heliothripini such as *Parthenothrips* and *Hercinothrips* for example. Besides the wings, *Arachisothrips* can be distinguished from the rest of the tribe by the combination of a striate pronotum, elongate antennae, bowling pin shaped tibiae, and head features.

No genus resembles *Arachisothrips* so much as does the Oligocene *Gerontothrips* (formerly known as *Archaeothrips* Priesner). Although *Gerontothrips* does not have a bulged fore wing, it has an exceptionally broad wing surface with hexagonal reticulations suggestive of *Arachisothrips*. The enlarged cheek pouch behind the eyes, the reticulate head,

EXPLANATION OF PLATE

Arachisothrips bonetti, sp. nov. (♂). FIG. 1. Dorsal aspect of head. FIG. 2. Apical segments of right antenna.

Arachisothrips millsi, sp. nov. (♀). FIG. 3. Right antenna. FIG. 4. Dorsal aspect of fore wing. FIG. 5. Ventral aspect of wings and position of hind leg at rest.



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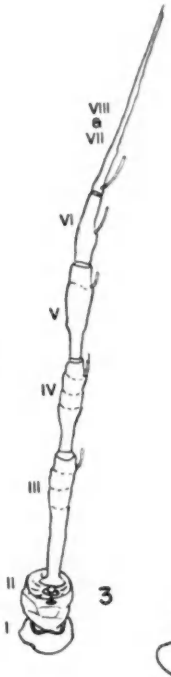

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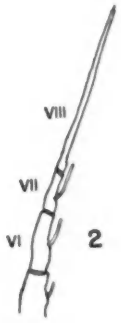

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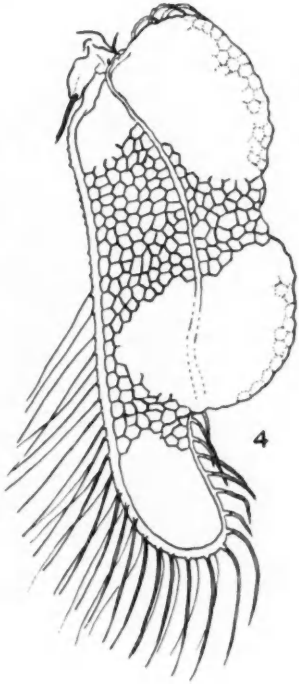

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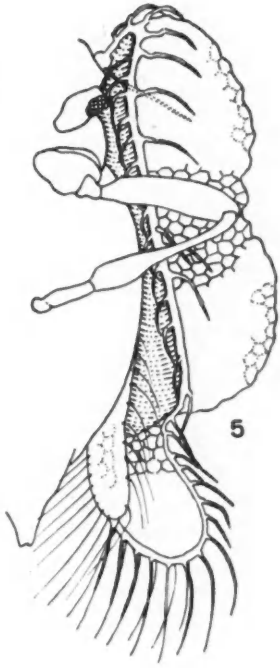

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the form of the antennae although short, and the shape and arrangement of the costal wing setae of *Gerontothrips* are additional similarities to *Arachisothrips*. *Gerontothrips* could be, most likely, the direct forerunner of the peanut-winged thrips.

Arachisothrips millsi, sp. nov.

Female (macropterous):—Length, exclusive of the antennae, about 0.75 mm. Color generally yellow; pterothorax and legs darker yellow; second, fifth, sixth, and seventh antennal segments, a median band across the middle of the bulged part of the fore wing and a small band just beyond this bulge, brown; ocellar pigment purple in Hoyer's mounting media.

Head similar to fig. 1 but with ocelli and indentation behind eyes slightly deeper; antennae seven segmented, fig. 2; wings, figs. 4 and 5; ovipositor small, with about six rows of teeth on each side.

Male (macropterous):—Length, exclusive of the antennae, about 0.5 mm. Similar to female except for characteristics pertaining to the male as mentioned in the generic description. Abdominal color of paratype male darker, yellowish brown.

Holotype:—Female; Jamaica, Hardwar Gap, Portland Parish; May 9, 1950; (H. B. Mills); sorted from Berlese sample of ground debris and mosses from moist semi-shaded bank in cloud forest at 4000 feet.

Allotype:—Male; same data as for holotype.

Paratype:—Male; same data as for holotype except from debris composed mostly of *Selaginella*.

The accompanying key should aid in the separation of this species from the following new species, ***boneti***.

Arachisothrips boneti, sp. nov.

Male (macropterous):—Length, exclusive of antennae, about 0.75 mm. General body color light brownish yellow; abdomen, antennal segments two, five, six, seven and eight, a median band across the middle of the bulged part of the fore wing and a small band just beyond this bulge, brown.

Head, fig. 1; antennae eight segmented, apical segments, fig. 3; wings as in figs. 4 and 5, but with only a single row of posterior fringe setae or spines on the fore wing.

Female:—Unknown.

Holotype:—Male; Mexico, Necaxa, Puebla; April 12, 1946; (F. Bonet); extracted from Berlese sample of ground litter.

The larger size of the male and the retention of the more generalized condition of eight segments in the antennae possibly indicate that this species is closer to the prototype of the genus than is ***millsi***.

KEY TO THE SPECIES

Antennae 8 segmented; abdomen brown; from Mexico..... **boneti**
Antennae 7 segmented; abdomen yellow to yellow brown; from Jamaica.... **millsi**

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1949. Genera Thysanopterorum. Bull. Soc. Fouad Ier Entom. 33: 131. (*Gerontothrips* proposed as new name for *Arachaeothrips* Pr., preoccupied.)

THE RELATION BETWEEN MINERALS, B-COMPLEX VITAMINS AND MITE POPULATIONS IN TOMATO FOLIAGE[1]

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Investigations on the mineral nutrition of the two-spotted spider mite, *Tetranychus bimaculatus* Harvey, have been reported in an earlier publication (Rodriguez, 1951). A study of the B-complex vitamin content of the host plant, to ascertain possible effects of vitamins as well as minerals on mite populations, developed out of those investigations.

Trager's review (1947) cites the work of several investigators who have established the fact that a number of insects require one or more members of the vitamin B-complex. Investigations in the vitamin requirements of the leaf-feeding forms are meager; however, such growth factors are found in comparative abundance in green foliage. Beck, Lilly and Stauffer (1949) stated that the larvae of the European corn borer did not grow on a purified diet in the absence of yeast or some other source of vitamins.

A number of workers have demonstrated the relationship between mineral supply and the vitamin content of plants. Watson and Noggle (1947) found that a deficiency of any one of the major elements in the nutrient solution decreased the riboflavin content of the oat plant; deficiency in nitrogen exerted the greatest effect. McCoy, Free, Langston and Snyder (1949) reported similar effects of major element deficiencies on niacin in the oat plant, with deficient nitrogen again responsible for the greatest decrease in the vitamin. Tomato fruits and foliage grown in complete nutrient solutions assayed slightly higher in riboflavin than those grown in solutions low in boron and manganese (Gum, Brown and Burrell, 1945). Furthermore, in the studies of Lyon and Beeson (1948), riboflavin and niacin in turnip greens were associated with increased manganese supply and high concentrations of boron in nutrient solutions effected an increase in thiamine and niacin concentration, while high concentrations of iron had no effect on any of the three vitamins.

In the work presently reported, isolated female mites were allowed to develop on tomato plants grown in nutrient culture on various levels of nitrogen and phosphorus and the number of progeny which developed was considered the criterion of response to mineral supply.

[1]Permission for publication of this paper is granted by the director of the Kentucky Agricultural Experiment Station. A portion of this work was conducted when the authors were employed at the Ohio Agricultural Experiment Station. Acknowledgment is made of the assistance rendered by Dr. C. H. Hunt of that station in certain vitamin analyses. The junior author is not a member of the Kentucky Agricultural Experiment Station staff.

Foliage analysis established mineral absorption as one of the variables. Analyses for thiamine, riboflavin and niacin were made on the foliage of the tomato plants; thus there could be determined primarily the relationship between mineral supply and absorption and vitamin elaboration in this plant, then the relationship, if any, between vitamin content and mite development.

EXPERIMENTAL METHODS

Four plants (replications) were grown on each of four levels of nitrogen supply (100, 200, 400 and 800 parts per million) and three levels of phosphorus supply (5, 20, and 40 ppm.). The complete nutrient solution considered optimum for growing tomatoes was used as one level of each element and contained 200 ppm. nitrogen and 20 ppm. phosphorus.

The total mite population which developed was determined for each plant, as were the contents of major and minor elements absorbed and vitamins elaborated (expressed as per cent dry weight and micrograms per gram dry weight of foliage, respectively).

The methods employed in the nutrient culture of the tomato plants, introduction of mites, preparation of the foliage samples and analyses for the mineral elements have been described in detail elsewhere (Rodriguez, 1951).

Thiamine determinations followed Gustafson (1947) in his modification for plant tissue of the thiochrome method of Connor and Straub (1941), with the following slight changes: takadiastase instead of clarase was used to digest the samples, activation of the decalso and elution of the thiamine were effected with sodium chloride instead of potassium chloride, the isobutyl alcohol layer was not treated with anhydrous sodium sulfate as this step was found to make no difference in the readings, and the concentration of the quinine sulfate solution was adjusted to .075 μg/ml. for the Coleman Electronic Photofluorometer which was used in making the determinations.

The method of Cooperman and Elvehjem (1944) for extracting riboflavin from oat tissue was found to be satisfactory for tomato foliage. The microbiological assay for riboflavin described by Snell and Strong (1939) was used, as were the adaptations by Hunt, Ditzler and Bethke (1947) of Krehl, Strong and Elvehjem's determination of niacin (1943). *Lactobacillus casei* E was used for riboflavin and *Lactobacillus arabinosus* 17–5 for niacin assays. Duplicate tubes of three levels of sample were assayed. An attempt was made to measure thiamine with *Lactobacillus fermentum* but this was abandoned because some of the foliage samples contained a growth inhibitor for that particular strain of *Lactobacillus*.

To determine the influence of mineral supply on vitamin content, an analysis of variance test (single classification) was performed on the values obtained for each vitamin and the minimum significant difference between means of the four replicates on each mineral level was calculated. To determine relationships within the variables (per cent mineral absorbed, vitamin content, and population), the following procedure was followed: correlations were made of the values obtained for individual plants— of the vitamins each with the other, of each vitamin

with each mineral, and of each vitamin with population. Tests for the significance of correlation coefficient r were conducted.

RESULTS AND DISCUSSION

Analysis of variance performed on the vitamin values of the tomato foliage samples resulted in F values ascribable to treatment which were significant at the 1% level for both riboflavin and niacin (7.97 and 36.61, respectively, with degrees of freedom for treatment and error 5 and 18). Differences in thiamine due to treatment occurred but were found to be not significant.

Increasing the supply of nitrogen (from 100 to 800 parts per million) tended to increase the three vitamins in the foliage (Table I). The 400 and 800 ppm. levels produced foliage of a significantly higher riboflavin

TABLE I

MEAN VALUES FOR VITAMIN CONTENT OF TOMATO FOLIAGE GROWN IN VARIED SUPPLY LEVELS OF NITROGEN AND PHOSPHORUS, AND THE MITE POPULATION THAT DEVELOPED ON THE FOLIAGE

MINERAL SUPPLY LEVEL (ppm.)	MITE POPULATION[1]	VITAMIN CONTENT (μg./gm. dry wt.)[1]		
		Thiamine	Riboflavin	Niacin
100 N, 20 P	749	.72	10.3	54.7
200 N, 20 P[2]	647	.72	10.8	56.2
400 N, 20 P	636	.87	14.5	65.9
800 N, 20 P	230	.80	15.7	110.3
200 N, 5 P	202	.67	10.0	43.8
200 N, 40 P	128	.56	10.1	42.8

[1]Mean of four replicates. Minimum significant differences between vitamin content means are as follows:
Thiamine, 0.32, 5% level.
Riboflavin, 2.7, 5% level; 3.7, 1% level.
Niacin, 12.2, 5% level; 16.7, 1% level.
[2]Standard Solution Level.

content than did the 100 and 200 ppm. levels; however, neither member of each pair was significantly different than the other member of that pair. The 100 and 200 ppm. levels produced foliage having practically the same niacin content; each added increment of nitrogen above 200 ppm. effected a marked increase in this vitamin. The 800 ppm. foliage contained twice as much niacin as did the foliage grown on the two lower nitrogen levels. The two vitamins were elaborated concomitantly with each other and with absorbed nitrogen.

These results are in accord with the findings of Watson and Noggle (1947) and McCoy et al. (1949) that nitrogen deficiency in the nutrient solution decreased riboflavin in the young oat plant.

In the nitrogen study, both riboflavin and niacin exhibited correlations with numerous absorbed minerals as well as with population (Tables II, III). Both vitamins were related negatively to population but this effect was significant only in the case of niacin. Both were

TABLE II

MINERAL ANALYSES OF TOMATO FOLIAGE GROWN IN VARIED SUPPLY LEVELS OF NITROGEN AND PHOSPHORUS[1]

MINERAL SUPPLY LEVEL (ppm.)	PER CENT MINERAL ABSORBED (dry wt.)[2]									
	N	P	K	Ca	Mg	Na	B	Mn	Cu	Total Ash
100 N, 20 P	3.27	.204	3.39	9.40	1.06	.189	.028	.0041	.026	26.4
200 N, 20 P[3]	3.61	.144	3.72	6.68	.86	.132	.024	.0019	.019	23.3
400 N, 20 P	4.43	.376	4.30	3.76	.61	.165	.042	.0019	.049	20.4
800 N, 20 P	6.11	1.388	2.82	1.75	.33	.344	.160	.0019	.047	15.7
200 N, 5 P	3.07	Trace	4.67	6.67	.96	.223	.028	.0037	.027	24.3
200 N, 40 P	3.01	Trace	4.49	6.75	.92	.206	.030	.0037	.033	24.4

[1]Data from Rodriguez, 1951.
[2]Mean of four replicates.
[3]Standard Solution Level.

TABLE III

CORRELATION COEFFICIENTS (*r*) SHOWING RELATION BETWEEN VITAMINS, MINERALS AND MITE POPULATIONS IN TOMATO FOLIAGE

VARIABLE	*r* VALUES	
	Nitrogen Study[1]	Phosphorus Study[2]
Riboflavin with:		
Niacin	+0.811†	+0.801†
Population	−0.270	.....
Nitrogen	+0.823†	+0.451
Phosphorus	+0.709†	.....
Potassium	.....	−0.569
Calcium	−0.783†	.....
Magnesium	−0.663†	.....
Boron	+0.652†	.....
Manganese	−0.621*	.....
Copper	+0.677†	.....
Total Ash	−0.771†	.....
Niacin with:		
Riboflavin	+0.811†	+0.801†
Population	−0.581*	+0.769†
Nitrogen	+0.955†	+0.833†
Phosphorus	+0.899†	+0.495
Potassium	−0.691†	−0.869†
Calcium	−0.794†	.....
Magnesium	−0.781†	.....
Sodium	.....	−0.688*
Boron	+0.939†	.....
Manganese	−0.471	−0.799†
Copper	+0.539*	−0.646*
Total Ash	−0.873†	−0.688*

[1]n = 16; significant *r* at 5% level, 0.497; at 1% level, 0.623.
[2]n = 12; significant *r* at 5% level, 0.576; at 1% level, 0.708.
*Significant at 5% level.
†Significant at 1% level.

correlated positively with nitrogen, phosphorus, boron and copper, and negatively with calcium, magnesium, manganese and total ash (niacin with manganese did not reach significance). Niacin was also negatively correlated with potassium. Thiamine content was not noticeably related to any other variable in this study. The relationship

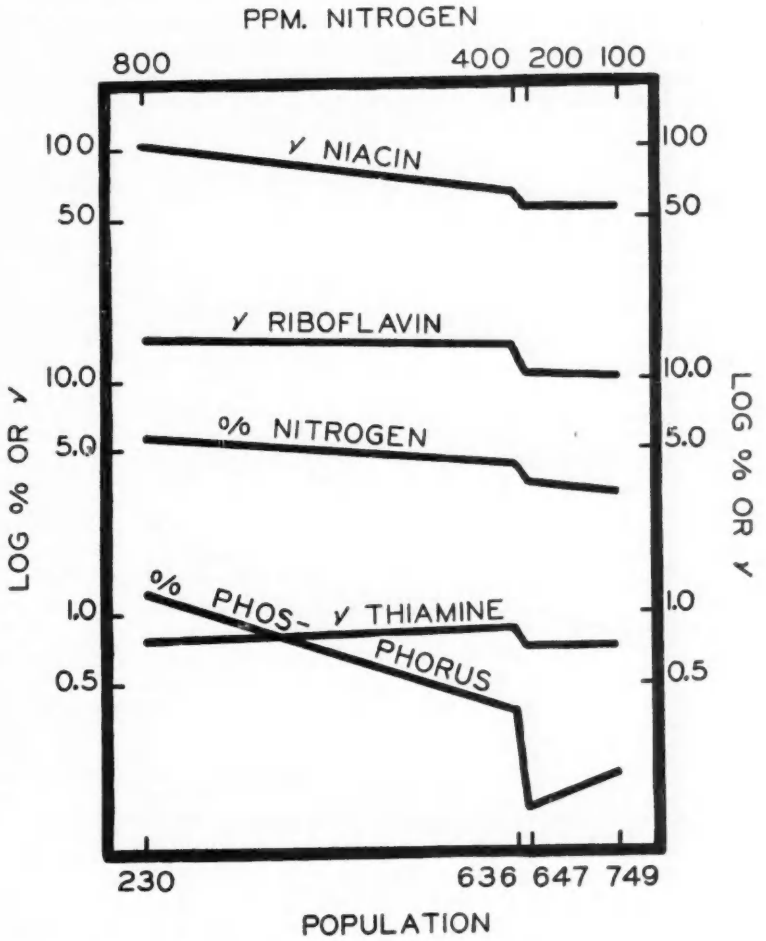

FIG. 1. The relationship (semi-log) of mite population and nitrogen supply to absorbed nitrogen and phosphorus and elaborated B-complex vitamins in tomato foliage.

of population and nitrogen supply to the factors discussed above is shown graphically in figure 1.

Phosphorus supply and absorption did not affect riboflavin. The standard solution or optimum level of phosphorus, 20 ppm., produced foliage containing significantly more niacin (5% level) than the foliage grown on either the low or high phosphorus levels. Absorbed phosphorus was not directly related to the phosphorus supply as the 5 and 40 ppm. levels produced foliage in which only a trace of phosphorus was detected

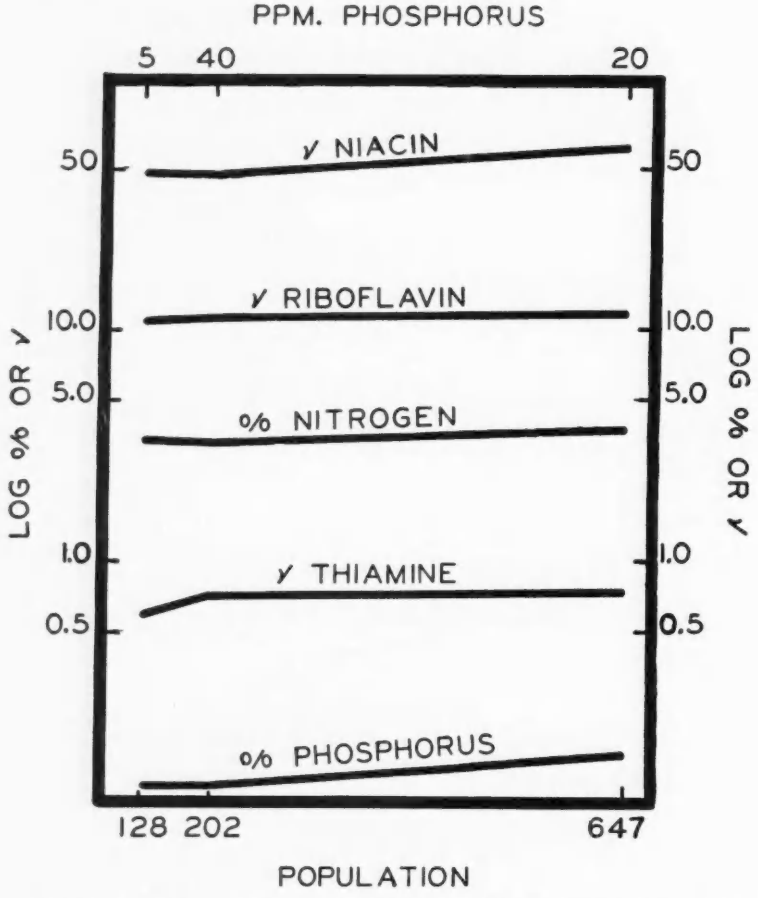

FIG. 2. The relationship (semi-log) of mite population and phosphorus supply to absorbed nitrogen and phosphorus and elaborated B-complex vitamins in tomato foliage.

(Table II). The elaborated niacin therefore followed the same pattern as the absorbed phosphorus and was positively correlated with it in the phosphorus study; this also occurred in the nitrogen study.

In the mineral nutrition studies reported earlier (Rodriguez, 1951), absorbed phosphorus reversed the type of correlation with population from negative in the nitrogen study to positive in the phosphorus study. The same reaction was demonstrated by niacin, which was correlated positively with population to a highly significant degree in the latter study (Table III).

Significant correlations of vitamins with the other absorbed minerals were less numerous in the phosphorus study than in the nitrogen study but several were noted. Thiamine exhibited a slight positive relationship to absorbed nitrogen but the r value of $+0.350$ was not significant. Riboflavin and niacin were again positively correlated with each other; both were positively correlated with nitrogen and negatively correlated with potassium. Niacin was negatively correlated also with sodium, manganese, copper and total ash. The relationship of population and phosphorus supply to the factors discussed above is shown graphically in figure 2.

The relationships of the B-complex vitamins to two-spotted spider mite development in these studies appeared to be inconclusive. Thiamine was not related at all; riboflavin was negatively (not significantly) related in the nitrogen study; niacin was related both ways in the two separate studies. If the mite requires these vitamins, apparently the lowest levels elaborated in the foliage grown in the nitrogen study, where relationships were negative, were sufficient for optimum development. It is possible that the niacin content of the foliage grown on the high and low phosphorus levels, being significantly lower than the content of the foliage grown on the standard solution level, was below the optimum nutritional level of this vitamin for the mites, so that the variations in niacin elaboration as well as mineral absorption may have been responsible for mite population fluctuations, or if not responsible, at least directly related.

SUMMARY

Foliage from tomato plants grown in nutrient culture on varied levels of nitrogen and phosphorus supply was analyzed for absorbed major and minor elements, and for the B-complex vitamins thiamine, riboflavin and niacin. Populations of two-spotted spider mite which developed from female mites isolated on the plants were determined. A previous publication set forth the relationships between minerals and populations; in the present study, the relationships of the vitamins to the minerals and populations were investigated.

Increasing the nitrogen supply tended to increase the content of the three vitamins in the foliage, significantly in the case of riboflavin and niacin. About twice as much niacin was elaborated when nitrogen was increased from 100 or 200 to 800 ppm. Riboflavin and niacin were elaborated concomitantly with each other and with absorbed nitrogen and phosphorus. Correlations of both positive and negative types were demonstrated between the vitamins and some of the other absorbed minerals.

Thiamine was not significantly related to any other variable investigated.

The relationships of riboflavin and niacin to mite development

appeared inconclusive. Riboflavin was negatively but not significantly correlated with population in the nitrogen study; niacin was significantly correlated with population, negatively in the nitrogen study and positively in the phosphorus study. It is suggested that a slightly different range of niacin elaboration in the two studies may have been responsible for the two types of correlations demonstrated.

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DESCRIPTIONS OF TWO NEW SPECIES OF SIMULIUM (DIPTERA, SIMULIIDAE) FROM GUATEMALA[1]

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Simulium (Byssodon) benjamini, new species

Amongst collections of *S.* (*L.*) ***samboni*** made near Poctún, Petén, Guatemala, one of the pupae developed into an adult that varied drastically from the others in the lot. Unfortunately, it was not distinguished in the field and it was not until the adult was examined in the laboratory that the distinctiveness of the species was noted. Since it was not considered desirable to describe the species as new from a unique specimen, it was held until further specimens became available. The additional collections consist of three reared females and their pupal cases that were collected in Alta Verapaz, Guatemala. This species appears to belong to the subgenus *Byssodon* Enderlein 1925 on the basis of the form of the male genitalia, general color of the female, and strong basal spur on posterior claw of female. To date, this subgenus has been reported from South America and Mexico but never from Guatemala or any other Central American country.

Male.—2.1 mm. long.

Head: Holoptic. Eyes very dark, reddish-brown. Antennae 330 μ long, 11-segmented; segment three shorter than segments one and two or four and five taken together, longer than segment 11; slender, the apical segments wider than basal segments; basal five segments brown, the others somewhat darker. Palpi black. Clypeus black, covered with white pruinosity and with irregularly-distributed short, black hairs.

Thorax: Mesonotum velvety-brown, with two stripes of white pruinosity, wider anteriorly, extending longitudinally from anterior margin to prescutellar depression where they fuse with the white pruinosity of the latter area. Patch of white pruinosity lateral to each longitudinal stripe. Humeral angles somewhat lighter than mesonotum in general, each with transverse patch of white pruinosity. Mesonotum without true hairs, but with long, narrow, yellow, scale-like hairs on anterior and lateral margins and on region of prescutellar depression. Pleura of mesothorax velvety-brown, covered with white pruinosity. Scutellum velvety-brown, with long black hairs on sides; midline bare. Postnotum velvety-brown, with triangular patch of grey pruinosity extending from anterior to posterior margin, the apex of patch being

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posterior. Stem of halter brown, the knob yellow. Wings, 1.8 mm. long and 0.85 mm. wide; Sc pilose along basal fifth (3 hairs); R_1 with spines and few hairs along distal half; R_{2+3} simple, pilose along distal four-fifths; Cu_2 arcuate; discal cell absent.

Legs: Leg 1—Length, 2.0 mm.; coxa and trochanter brown; femur with basal two-thirds brown, the apical third light brown; tibia and tarsus dark brown. Leg 2—Length, 1.7 mm.; coxa, trochanter, and femur dark brown; tibia black with yellow basal ring; tarsus yellow. Leg 3—Length, 2.1 mm.; coxa, trochanter, and femur dark brown; tibia dark brown, with yellow basal ring; basal two-thirds of basitarsus tan, apical third dark brown; segments two through five yellow; calcipala well-developed, surpassing the pedisulcus; pedisulcus well-formed, on basal third of second tarsal segment.

Abdomen: Tergite and pleurites of segment one velvety-brown, the pleurites being clothed with long, tan-colored hairs; tergite of segment two black, with white pruinosity. Other segments black, pleurae of segments five, six, and seven white-pruinose.

Genitalia: Sidepiece longer than wide. Clasper short, longer than wide, one-half as long as sidepiece; conical, with rounded apex; subapical spine heavy, blunt, branching into two about half-way along its length. Both sidepiece and clasper with numerous long, stout, spine-like hairs, some of them on the sidepiece reaching almost to apex of clasper. Adminiculum wider than long, with large, sclerotized, very much expanded basal processes; body of adminiculum with conical protuberance at apical end, the base of which appears to arise from the ventral surface; body of adminiculum with hairs, those along apex longer and stouter. Adminicular arms with six long, sharp teeth, well-spaced, and arranged in linear fashion, without hairs; lateral plate small, quadrangular, sclerotized, with numerous wrinkles.

Female.—2.0 mm. long.

Head: Dichoptic. Eyes shiny black; fronto-ocular triangle 72 μ high, the base 100 μ. Antennae short and stubby, 400 μ long, 11-segmented, very slightly tapering; segment three shorter than segments one and two taken together but longer than four and five taken together, shorter than segment 11; light brown. Palpi brown. Frons, clypeus, and occipital region black, white-pruinose, the occipital region also covered with short black hairs. Bucco-pharyngeal apparatus very heavily sclerotized, the cornua bifid; with two evenly-spaced, long extensions from the median space; each extension appears to be composed of three, sharply-pointed, long spines; between the two extensions are found seven short spines, the center one shorter than the others, there are two short spines surrounding each of the extensions; also, between each extension and the closest cornu, are found three minute spines; there are approximately 23 spines in all; the structure of the bucco-pharyngeal apparatus is sufficient to distinguish this species from all other Guatemalan species.

Thorax: Mesonotum velvety-brown; two stripes of white pruinosity, wider anteriorly, extending from anterior border to prescutellar depression which is also white-pruinose; wide band of white pruinosity along each lateral margin; patch of white pruinosity on midline, one-quarter distance back from anterior margin; humeral angles velvety-brown

with white pruinosity; no scale-like hairs on mesonotum, a few short yellow hairs present on prescutellar region. Scutellum velvety-brown, somewhat lighter than mesonotum, with two transverse rows of long black hairs. Postnotum same color as mesonotum, with white pruinosity but without pilosity. Stem of halter dark tan; knob tan. Wings, 2.2 mm. long; maximum width, 1.0 mm.; Sc pilose along basal half; R_1 with spines along distal third and with sparse hairs near base; R_{2+3} pilose except for basal one-seventh; Cu_2 arcuate; discal cell absent.

Legs: Leg I—Length, 2.1 mm.; entire leg brown. Leg 2—Length, 1.9 mm.; coxa dark brown, trochanter brown; femur brown, tibia brown with light brown basal ring; basitarsus and second tarsal joint light brown, the basitarsus three times as long as second joint; segments three through five light brown. Leg 3—Length 2.3 mm.; coxa dark brown, trochanter brown; femur with basal two thirds brown, apical one-third dark brown; tibia with basal one-fifth tan; apical four-fifths dark brown; basitarsus 4.9 times as long as second joint, its basal three-fifths tan, apical two-fifths and remainder of tarsal segments dark brown; calcipala and pedisulcus well-developed, the former almost reaching the pedisulcus; pedisulcus at middle of second tarsal joint; claw well-developed; also very small basal secondary claw.

Abdomen: Segment one with tergite and pleurae brown, the pleurae with long tan hairs reaching the third segment; tergite of segment two brown with white pruinosity; tergites of remaining segments brown, the pleurae dark brown; sternites of all segments tan. Short tan-colored hairs on posterior margins of tergites of segments five, six, seven, and eight.

Genitalia: Cercus dome-shaped, almost as long as high, covered with few long, strong hairs and with many short, scale-like hairs, all directed posteriorly. Anal lobe almost oval, about same size as cercus and with similar investiture. Genital rod narrow with no basal dilatation; arms with somewhat quadrangular expansions, the outer basal angle rather sharply pointed and well-sclerotized; two small tooth-like processes on inner edge. Ovipositor 40 μ long and 28 μ high, somewhat club-shaped.

Pupa.—Cocoon: Greatest length, 2.5 mm.; greatest width, 1.1 mm. Wall-pocket type, without collar between anterior aperture and substratum; rim around anterior aperture not noticeably thickened, the dorsal margin with broad anterior prolongation on some specimens. Texture of the case parchment-like, the strands forming it coarse and rather loosely woven. Floor of case complete along posterior half. Case extends anteriorly over about one-half the cephalothorax.

Filaments: Respiratory apparatus composed of short trunk which almost immediately divides into an outer branch and, slightly distal to this branch, into inner dorsal and inner ventral branches, the latter two emerging at the same level.

Outer branch—This branch bifurcates at a point approximately one-fourth of the distance from its origin.

Inner dorsal branch—At a point about one-sixth of the distance from its origin, it subdivides into two, and at about one-quarter the way from its origin, one of these two branches divides again, thereby forming three branches.

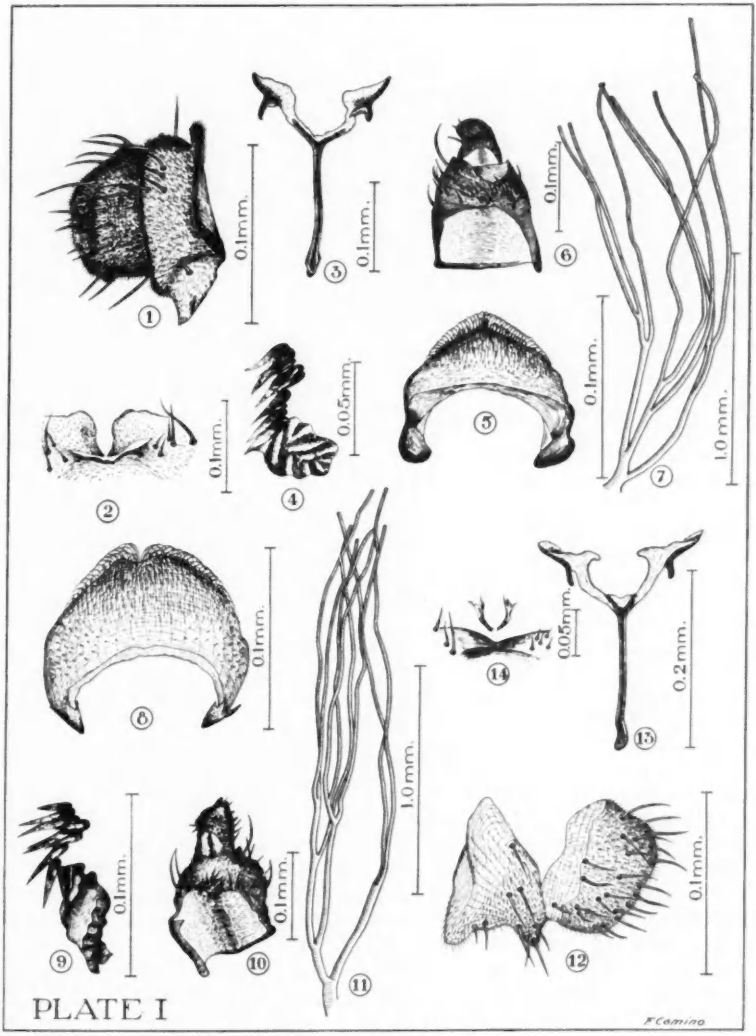
Inner ventral branch—At a point about three-tenths of the way from its origin, it subdivides into two, and at about two-fifths the distance from its origin, one of the two branches further subdivides, making three branches in all.

Thus, the respiratory apparatus is composed of eight filaments, the maximum length being 2.2 mm. and the width varying from 360 μ near the bases to 12 μ near the apices. All filaments appear rather heavy-walled, with pseudo-annulations which are somewhat accentuated by what appear to be minute hairs arranged in almost regular transverse rows over the entire surface.

Simulium (*Byssodon*) *benjamini* is easily separated from *S.* (*B.*) *ganalense* Vargas, Martínez and Díaz by the number of pupal respiratory filaments, the latter species having only six on each side. *S. benjamini* is separated from *S.* (*B.*) *quadrivittatum* Loew as follows: In *benjamini* the bucco-pharyngeal apparatus of the female contains approximately 23 spines, each of the two extensions being composed of three long, sharply-pointed spines; in *quadrivittatum*, there are approximately 33 spines, each of the extensions in the form of a cone bearing seven short spines emerging at different levels along its surface. The mesonotum of the female *benjamini* is velvety-brown and the subapical spine of the male clasper is bifid; in *quadrivittatum* the mesonotum is jet black and the clasper spine is simple. The color patterns of the legs of the female and the structure of the anal lobe and genital rod differ considerably between the two species. The posterior tarsal claw of the female *benjamini* has a small secondary spur near the base while in *quadrivittatum* it is simple. In the pupal respiratory apparatus of *benjamini* the primary ramifications of the three principal trunks take place closer to the bases than in *quadrivittatum*, while the secondary bifurcations of the inner dorsal and inner ventral trunks occur much closer to the point of primary branching in *benjamini* than in *quadrivittatum*.

Ecological Notes.—*Simulium* (*Byssodon*) *benjamini* has been found in only two streams, Río Sokchá, Poctún, Petén, and in a stream (name not known) in Cobán, Alta Verapaz, both streams being part of the Atlantic watershed. The collections were made at altitudes of 1500 feet and 5000 feet. At the point of collection, the Río Sokchá was 39 inches wide, three to 15 inches deep, with a current of 20 inches per second; the temperature was 20° C. and the pH, 7.2. The collections were both made during the month of November, at the beginning of the dry season. Other species found developing in the same streams were: *S.* (*S.*) *metallicum*, *S.* (*L.*) *samboni*, *S.* (*S.*) *ochraceum*, and *S.* (*L.*) *downsi*.

Types—*Holotype:* Male (Accession 3N-4) reared from pupa collected in the Río Sokchá, Poctún, Petén on November 11, 1948, by Herbert T. Dalmat, Luis de la Torre, and J. Onofre Ochoa A.; genitalia, legs, wings, and head mounted on four slides; pupal exuvium and cocoon in alcohol. *Allotype:* Female (Accession 13N-1) reared from pupa collected in a stream (name unknown) in Cobán, Alta Verapaz on November 19, 1944, by G. B. Fairchild; genitalia, legs, bucco-pharyngeal apparatus, head, and wings, mounted on five slides; the pupal skin and cocoon in alcohol. *Paratypes:* One female (13N-5) and one male



FIGS. 1 through 7. *Simulium* (*Byssodon*) *benjamini*, n. sp.: 1–3, cercus and anal lobe, ovipositor, and genital rod of female; 4–6, adminicular arm and lateral plate, adminiculum (ventral view), and side piece and clasper of male; 7, respiratory filaments of pupa. FIGS. 8 through 14. *Simulium* (*Lanea*) *colvini*, n. sp.: 8–10, adminiculum (ventral view), adminicular arm and lateral plate, and side piece and clasper of male; 11, respiratory filaments of pupa; 12–14, cercus and anal lobe, genital rod, and ovipositor of female.

(13N-6) and their respective pupal skins and cocoons; six slides, including genitalia, legs, head, bucco-pharyngeal apparatus, and wings, prepared of the female, and five slides, including genitalia, head, legs, wings and bucco-pharyngeal apparatus, prepared of male; the pupal filaments of 13N-5 mounted on slide, the pupal exuvium and cocoon, as well as the exuvium and cocoon of 13N-6, preserved in alcohol. Three males (13N-2, 4, 7) and two females (13N-3, 8) mounted on minuten nadeln, their respective pupal exuvia and cocoons preserved in alcohol. Two pupae (13N-9), both preserved in alcohol, the filaments of one mounted on slide.

Holotype and allotype to be deposited in the collection of the United States National Museum; paratypes in collection of author. This species has been named in memory of my father, Mr. Benjamin Dalmat.

Simulium (Lanea) colvini, new species

This species was found in the lowlands along the western border of Guatemala, near the Río Suchiate which divides this country from Mexico.

Male.—2.4 mm. long.

Head: Holoptic. Eyes light reddish brown. Antennae 430 μ long, 11-segmented, slightly tapering; segment three equal in length to segments one and two taken together, but longer than either segments four and five taken together or than segment 11; antennae light brown, basal two segments somewhat lighter. Palpi black. Clypeus black with white pruinosity and with few, irregularly-distributed, short, black hairs.

Thorax: Base color yellow; on either side of midline of mesonotum there is a narrow longitudinal stripe of white pruinosity extending from anterior margin to prescutellar depression which is also white-pruinose; humeral angles yellow, covered with white pruinosity; mesonotum not invested with hairs but rather with few long, narrow, yellow, scale-like hairs on its anterior half and on depressed prescutellar area. Pleura tan, covered with white pruinosity. Scutellum light yellow with strong, long black hairs on sides, these almost reaching midline. Postnotum velvety, light yellow, covered with white pruinosity. Stem of halter brown, the knob tan. Wings, 1.9 mm. long and 0.94 mm. wide; Sc pilose along basal one-sixth (three hairs); R_1 completely pilose, hairs more spine-like along distal two-thirds; R_{2+3} simple, pilose along distal seven-eighths; Cu_2 arcuate; discal cell absent.

Legs: Leg 1—Length, 2.2 mm.; coxa, trochanter, and femur light brown; tibia with basal three-fourths light brown and apical fourth black; tarsus black. Leg 2—Length, 1.9 mm.; coxa bluish-black, trochanter, femur, and tibia yellow; tarsus black except for basal half of first segment which is yellow. Leg 3—Length, 2.2 mm., coxa bluish-black; trochanter yellow; femur yellow with black apex; tibia with basal half yellow and apical half black; basal two-thirds of basitarsus tan, apical third black; second tarsal segment with basal half tan, apical half black; segments three to five black; calcipala well-developed, not reaching pedisulcus; pedisulcus very small, situated on second tarsal joint, one third the distance from its base.

Abdomen: Segment one with tergite and pleurites yellow; the latter partially white-pruinose; tergite and pleurites with sparse short black hairs; segment two yellow, somewhat white-pruinose, and with few short black hairs; tergites of other segments black; pleurites of segments four, five, and six yellow, with white pruinosity, the other pleurites black; sternites tan with white pruinosity.

Genitalia: Sidepiece somewhat square, the width and length being equal; dorsal opening very large, following general contours of sidepiece itself, covering approximately five-sixths of sidepiece. Clasper less than one-half length of sidepiece, the apex truncate with one heavy spine arising on distal end, somewhat removed from inner angle; one extremely long spine arising from about middle of ventral surface; well-marked opening on basal half of clasper. Body of adminiculum circular, with sharply-pointed, sclerotized basal processes; apex somewhat prolonged to form a crown which is covered with long hairs; hairs on remainder of body of adminiculum shorter and appressed. Adminicular arms usually with ten teeth, the distal five being long and the other noticeably shorter; lateral plate small, quadrangular, hyaline, with numerous wrinkles that appear somewhat sclerotized.

Female.—1.9 mm. long.

Head: Dichoptic. Eyes yellowish-brown; altitude of fronto-ocular triangle about equal to base. Antennae 510 μ long, 11-segmented, very slightly tapering; segment three shorter than either segments one and two taken together, segments four and five together, or segment 11; light brown, the basal two segments still lighter. Palpi brown. Frons and clypeus black with white pruinosity. Occipital region black, with investiture of short yellow hairs. Cornua of bucco-pharyngeal apparatus very wide, shovel-like, and heavily sclerotized; median space hyaline with numerous, very small sclerotized teeth.

Thorax: Base color of mesonotum velvety-yellow; on either side of midline there is a longitudinal stripe of white pruinosity that extends from its anterior margin into prescutellar depression which is also white-pruinose; a wide band of white pruinosity is found on each of the lateral margins of mesonotum. Humeral angles light yellow, with white pruinosity. Mesonotum without pairs but with sparse, long, narrow, yellow, scale-like hairs on its anterior half and in the prescutellar depression. Scutellum light yellow, with short yellow hairs and long black ones along its sides. Anterior half of postnotum dark brown with white pruinosity, the posterior half light yellow without investiture of hairs. Stem of halters with dark brown base and tan apex, knob tan. Wings, 2.4 mm. long; maximum width, 0.97 mm.; Sc pilose along basal half; R_1 completely pilose, also with spines along distal two-thirds; R_{2+3} pilose except for basal one-tenth; Cu_2 arcuate; discal cell absent.

Legs: Leg 1—Length, 2.3 mm.; entire leg light brown except the tarsus which is black. Leg 2—Length, 2.0 mm.; coxa bluish-black, trochanter brown; femur light brown with bluish-black apex; tibia tan with blackish caste; tarsus black except for basal half of basitarsus which is tan; basitarsus 3.2 times as long as second tarsal joint. Leg 3—Length, 2.4 mm.; coxa and trochanter light brown; femur light brown with black apex; basal half of tibia light brown, apical half black;

basal two-thirds of basitarsus tan, the apical third black; second joint with basal half tan, apical half black; basitarsus 4.8 times as long as second joint; third through fifth joints black; calcipala well-developed but not reaching pedisulcus; pedisulcus present on basal third of second joint but very poorly developed; claw small with almost no basal heel.

Abdomen: Tergite and pleurites of segment one light yellow, the tergite invested with short, yellow hairs and the pleurites clothed with long, tan-colored hairs that extend posteriorly to the third segment; segment two light yellow; tergites of segments three through six and of segment eight black, their lateral regions tan; tergite of segment seven light yellow with an investiture of short yellow hairs; pleutires of segments three through eight bluish-black. Sternites tan.

Genitalia: Cercus somewhat higher than long, with few long, strong hairs, and numerous short, scale-like hairs, all directed posteriorly. Anal lobe rather narrow, extending beneath the cercus, with posteriorly-directed, ventral, finger-like projection which is more heavily sclerotized than the rest of the anal lobe and contains many very short hairs and some rather long ones. Genital rod with small, bulb-like dilatation; distal expansions somewhat triangular in shape, the inner basal angle and apical angle of each more heavily sclerotized, the apical angle also being sharply pointed; a rather long, heavily sclerotized, tooth-like process emerging from mid-region of outer margin of expansions. Ovipositor small, 32 μ by 8–10 μ (at widest point), somewhat harp-shaped.

Pupa.—Cocoon: Greatest length, 2.7 mm.; greatest width, 1.6 mm.; wall-pocket type without collar between the substratum and anterior aperture; rim around anterior aperture more heavily sclerotized, with a very short, but distinct anterior median prolongation; texture of case parchment-like, thin, with comparatively few strands forming it; case extends to not quite one-half of the cephalothorax; floor of case completely woven along posterior half and along lateral margins.

Filaments: Respiratory apparatus composed of extremely short trunk which divides almost immediately into an outer branch and inner branch, the latter subdividing somewhat distal to its origin into a dorsal and ventral branch. The ramifications are as follows:

Outer branch—This branch bifurcates at the level of the first ramification of inner dorsal branch, forming just two branches.

Inner dorsal branch—At point about one-fourth of its length, this branch divides into two, the more dorsal division dividing soon thereafter into two further divisions, making three branches in all.

Inner ventral branch—At point somewhere between the two subdivisions of the inner dorsal branch, the inner ventral branch subdivides into two, one of these two branches further subdividing into two at about the level of the most distal subdivision of the dorsal branch. There are formed a total of three branches.

Thus, the respiratory apparatus is composed of eight filaments, the maximum length being 2.4 mm. and the width varying from 340 μ near the base to 15 μ near the apices. The filaments are heavy-walled, with pseudo-articulations.

Simulium (*Lanea*) *colvini* belongs to the subgenus *Lanea* as defined by Vargas.[2] It appears closest to *S.* (*L.*) *downsi* Vargas, Martínez,

[2]Vargas, L., Martinez Palacios, A. y Diaz Najera, A. 1946. Simulidos de Mexico. Rev. Inst. Salub. Enferm. Trop. 7(3): 101–192.

and Díaz and to *S.* (*L.*) ***samboni*** Jennings, but can easily be distinguished from them by the following characters: The expansions of the genital rod of ***colvini*** have a long, heavily-sclerotized tooth-like process emerging from mid-region of outer margin and the ovipositor is small, with indentation on distal end; in ***downsi*** and ***samboni*** the expansions of the genital rod do not have the tooth-like process and the ovipositor does not have the apical indentation. The single terminal spine of the male clasper of ***colvini*** is removed from the apex while in ***downsi*** it is at the extreme apex of the clasper; the clasper of ***samboni*** has two well-developed apical spines. The adminiculum of ***colvini*** is rounded while that of ***downsi*** and ***samboni*** is somewhat angular on the sides. *S. colvini* can also easily be distinguished from the other two species by the ramifications of the pupal respiratory filaments.

Ecological Notes.—***Simulium*** (***Lanea***) ***colvini*** has been found at an altitude of 260 feet in only one stream (name unknown) between Malacatán and Ayutla, Department of San Marcos, near the Río Suchiate which divides Guatemala from Mexico. The larvae and pupae were found on narrow leaves, approximately one inch beneath the surface of the water. Other species that were found in the same stream were: *S.* (*D.*) ***pulverulentum***, *S.* (*S.*) ***metallicum***, and *S.* (*L.*) ***downsi***.

Types.—***Holotype:*** Male (Accession 13D-1) reared from pupa collected in a stream between Malacatán and Ayutla, Department of San Marcos, on July 18, 1951 by J. Onofre Och[illegible] A., Arden O. Lea, Jr., and Herbert T. Dalmat; genitalia, legs, head, and wings mounted on four slides; pupal exuvium and cocoon in alcohol. ***Allotype:*** Female (13D-8) reared from pupa collected with holotype; genitalia, legs, head, bucco-pharyngeal apparatus, and wings mounted in five slides; pupal exuvium and cocoon in alcohol. ***Paratypes:*** One male and two females (13D-7, 12, 9) reared from pupae collected with holotype; genitalia, legs, wings, head, and bucco-pharyngeal apparatus of male mounted on five slides; genitalia, legs, wings, head, and bucco-pharyngeal apparatus of each female mounted on five slides; pupal filaments of 13D-7 mounted on slide, the remainder of its pupal exuvium, its cocoon, and the pupal exuvia and cocoons of females preserved in alcohol. Four males and two females (13D-3, 4, 5, 6, 10, 11) mounted on minuten nadeln, their respective pupal skins and cocoons preserved in alcohol. Also 19 pupae (13D-16) and 16 larvae (13D-17) preserved in alcohol, and 3 larvae (13D-18) mounted on slides.

Holotype and allotype to be deposited in collection of the United States National Museum; paratypes in collection of author. This species has been named for Dr. Colvin L. Gibson, Parasitologist and co-worker on the Onchocerciasis Project.

THE CULICOIDES OF THE WICHITA REFUGE, OKLAHOMA. TAXONOMY AND SEASONAL INCIDENCE[1]

(Diptera, Heleidae)

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The purpose of this study is to report the species of *Culicoides* found in the Wichita Mountains National Wildlife Refuge and to describe their seasonal incidence in that area. It is based on collections taken from a mosquito light-trap (New Jersey type) operated at the headquarters of the Refuge in 1947.

The trap was operated each night, with occasional exceptions, from the end of March until the end of October. After the mosquitoes were removed at the University (1947–1948), the remaining insects were stored in the University Museum. From these materials 7011 specimens of *Culicoides* were recovered in the spring of 1950. Some supplementary collections were also made in the summer of this year.

The 1947 location of the trap, on the west bank of Headquarters Creek, was somewhat protected from wind by vegetation and an adjacent building. Suitable hosts were likely to be available, and areas which could serve as proper breeding places were close to the location.

The genus *Culicoides* was represented in this material by specimens of 10 previously known species, including the undescribed male of *C. multipunctatus* Mall., one subspecies, and four new species.

MATERIALS AND METHODS

Specimens were preserved free in pill boxes or on cardboard points and were identified while dry with every part of the insect as nearly as possible in its natural state. Whenever clearing was necessary to remove doubt, a few dry duplicates were carefully selected to be used with the cleared specimens.

For clearing and mounting, the specimen was placed in a 10% potassium hydroxide solution heated to about 90° C. but never to the boiling point. It was transferred to acidified water (50 cc. water + 2

[1]The writer wishes to acknowledge his indebtedness to Dr. Melvin E. Griffith, who suggested this study and offered valuable advice throughout the work. He is also grateful to Dr. E. Harold Hinman, who supplied most of the publications used; to Mr. Leslie Ellis, for making the supplementary collections; to Dr. Willis W. Wirth, of the U. S. National Museum, for checking part of the material and solving many of the difficulties met during the work. Acknowledgments are also due to the Communicable Disease Center of the United States Public Health Service and the Oklahoma State Department of Health for providing and servicing the light-trap equipment; and to Mr. Ernest G. Greenwalt, Manager, Wichita Mountains Wildlife Refuge, for operating the light-trap.

drops of acetic acid) and then to a drop of glycerine on a slide. Sometimes it was necessary to tease the parts of the male genitalia apart for a clear description. When measurements of palpi and antennae were needed, it was often best to separate them from the head. For separating of the antennae and palpi or teasing apart the genitalia, minuten nadeln, mounted in delicate wooden applicators and with the tips bent at an angle, were used. Direct transference of the cleared specimen from the glycerine to P.V.A. was practiced for the preparation of permanent mounting.

THE RELATIVE ABUNDANCE OF THE SPECIES OF CULICOIDES IN THE WICHITA REFUGE

The species collected in this location could be definitely arranged according to their abundance into four groups:

	Approximate percentage
Group 1. Abundant (over 10% of specimens)	
C. hieroglyphicus Mall.	25 %
C. stellifer Coq.	22.3%
C. haematopotus Mall.	17.3%
Group 2. Common (5–10% of specimens)	
C. ousairani n. sp.	10 %
C. crepuscularis Mall.	8.8%
C. arboricola R. and H.[2]	7.3%
Group 3. Occasional (1–5% of specimens)	
C. multipunctatus Mall.	2.4%
C. variipennis Coq.	2.3%
C. nanus R. and H.	1.7%
C. guttipennis Coq.[2]	1.3%
C. weesei Khalaf.	.9%
C. salihi n. sp.	.7%
Group 4. Rare	
C. simulans R. and H. and *C. hinmani* n. sp.	

DESCRIPTIONS OF THE SPECIES

Culicoides multipunctatus Malloch

This is one of four species with clear wings found in the locality. The female only has been previously described.

Female:—Eyes separated. The four antennal segments preceding the last one but slightly elongated (fig. 1, C); the five terminal segments slightly shorter than the first eight segments of the antennal flagellum. Third segment of palpi (fig. 1, D) longer than the second, moderately swollen with a large shallow sensory pit; fifth segment slightly longer than the fourth. Spermathecae unsclerotized.

Male hypopygium (fig. 1, A and B):—End of the claspers not foot-shaped. Apicolateral processes well developed. Processes of the sidepiece exceptionally well developed, the inner processes having irregular curved serration. Arch of the aedeagus inverted-V-shaped with slender sides, the distal end bearing two projections of about the same length as the terminal portion of the aedeagus; a sclerotized collar, which probably corresponds to the structural modification of

[2]The material was not in a condition to distinguish the female of *C. villosipennis oklahomensis* n. subsp. from that of *C. arboricola* R. and H. and *C. guttipennis* Coq.

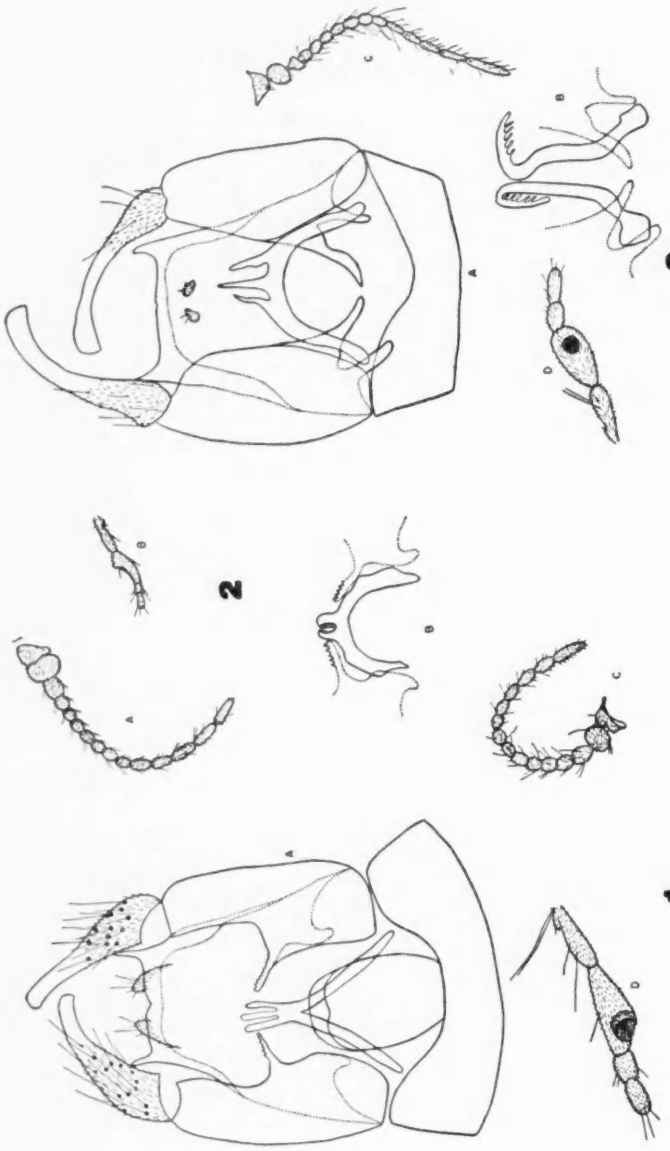

FIG. 1. *Culicoides multipunctatus* Mall. A., hypopygium without harpes; B., harpes; C., antenna; D., palpus.
FIG. 2. *Culocoides weesei* Kalaf A, antenna; B, palpus. FIG. 3. *Culicoides salibi* n. sp. A, hypopygium without harpes; B, harpes; C, antenna; D, palpus.

the ninth sternite of *C. hieroglyphicus* Mall, associated with the aedeagus, Harpes fused; the tip of their arch bearing two lobes.

Allotype, male, Wichita Refuge (Okla.), June 6, 1947; eighteen more male paratypes; deposited in the University of Oklahoma Museum.

Culicoides weesei Khalaf[3]

Only the female of this species has been recovered. It is like *C. hieroglyphicus* Mall. with respect to the unspotted wings, but is more likely to be confused with *C. simulans* R. and H. on account of the light coloration of the body and the approximate similarity in size. The latter species has, sometimes, very indistinct maculation of the wings which adds to the close similarity. The dark knees of *C. simulans* R. and H offer one basis of distinction.

Female:—Length, about 1.8 mm. Vertex and mesonotum brown covered with gray pruinescence; no distinct mesonotal pattern. Proboscis brown; palpi and antennae lighter in color. Eyes separated. Wings unspotted with macrotrichia well represented. Scutellum dull yellow. Legs yellow; unlike *C. salihi* n. sp., the knees are not dark. Last five segments of the antennal flagellum (fig. 2, A) subequal to the first eight; the last segment unlike that of *C. salihi* n. sp. in being not much longer than each of the preceding segments. Third segment of palpi (fig. 2, B) longer than the second and moderately swollen with a large, shallow, sensory pit; the last two segments subequal. Spermathecae two, very well sclerotized so as to appear dark; oval in shape, the base of the duct sclerotized for a much shorter distance than in *C. salihi* n. sp. A rudimentary spermatheca present; ring not distinct.

Holotype, female, Wichita Refuge (Okla.), June 15, 1947; about fifty female paratypes, Wichita Refuge (Okla.), 1947; deposited in the University of Oklahoma Museum.

Culicoides salihi, new species[4]

Closely similar in appearance to *C. weesei* kalaf but smaller in size and with dark knees.

Female:—A small species, about 1.1 mm. in length. Antennae, palpi, proboscis, and vertex light brown, in some specimens brownish yellow. Mesonotum brown with gray pruinescence; no distinct pattern. Humeral angles yellow, scutellum dull yellow, metanotum brown, halteres yellow. Eyes narrowly separated. Legs yellow, knees dark. Wings unspotted with macrotrichia well represented, more dense in cell R_5, extending down the wing through about two-thirds of the anal cell, but not present behind the two radial cells. Last five segments of the antennal flagellum (fig. 3, C) very little longer than the first eight; the last segment considerably longer than each of the preceding four. Third segment of the palpi (fig. 3, D) longer than the second and well swollen with a small, deep, sensory pit; last segment longer than the

[3]This species is named for Dr. A. O. Weese, Professor of Zoological Sciences, University of Oklahoma, Norman, Oklahoma. The description of the allotype (Khalaf, 1952, Jour. Kansas Ent. Soc. 25:65), from subsequent collecting, has already been published.

[4]This species is named after Mr. Sharif Salih, Instructor in Chemistry, Mosul, Iraq.

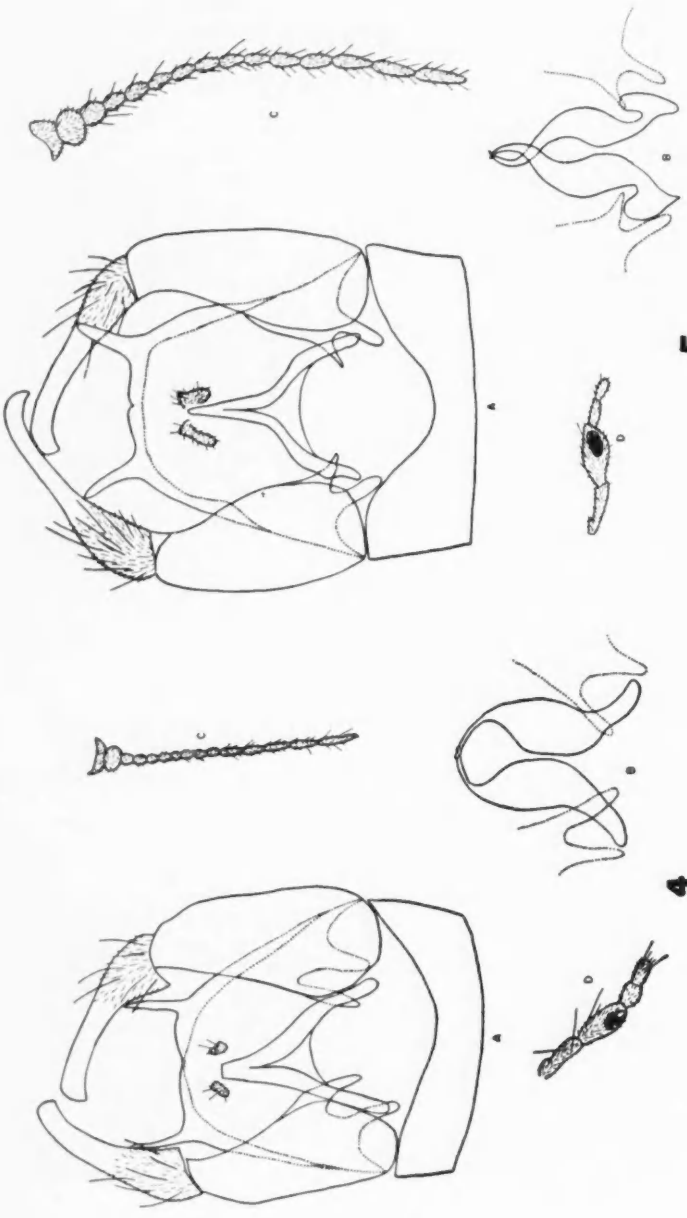

FIG. 4. *Culicoides hinmani* n. sp. A, hypopygium without harpes; B, harpes; C, antenna; D, palpus.
FIG. 5. *Culicoides ousairani* n. sp. A, hypopygium without harpes; B, harpes; C, antenna; D, palpus.

fourth. Spermathecae two, oval in shape, one about 48 μ in diameter, the other about 44 μ; in contrast with *C. weesei* Khalaf but lightly sclerotized. Base of duct sclerotized for about 18 μ; longer than the base of the duct of any other species in the locality. A rudimentary spermatheca and ring present.

Male hypopygium (fig. 3, A and B):—End of claspers not foot-shaped, but slightly swollen. The inner processes of the sidepiece approximate, better developed than the dorsal. Aedeagus with a high arch, wide even at the apex with a slender terminal portion; a posterior projection from the arch on each side of the terminal portion; these two projections shorter than the terminal portion, convergent at the base. Harpes separate; the stem of about the same width throughout; the tip curved and spiny.

Holotype, male, Wichita Refuge (Okla.), June 29, 1947; allotype, female, Wichita Refuge (Okla.), June 29, 1947; about 40 paratypes, Wichita Refuge (Okla.), 1947; all are deposited in the University of Oklahoma Museum.

Culicoides hinmani, new species[5]

Similar to *C. stellifer* Coq. but smaller in size, cell R^5 without apical light spot, and cell M^2 with light spot before the tip and another on vein M^2.

Female:—Very small in size, hardly 1 mm. long. Proboscis brown, antennae and palpi lighter. Last five segments of the antennal flagellum (fig. 4, C) quite elongate, especially the last one, about one-third longer than the first eight. Eyes practically touching. Third segment of palpi (fig. 4, D) longer than the second; swollen, with a moderately deep pit; fifth segment longer than the fourth. Mesonotum brown with a gray pruinescence which forms a pattern: a median dark vitta and two grayish submedian stripes that extend to the prescutellar depression; a wider grayish stripe outside each of the submedian stripes; outside these, two faint spots on each side; the dark stripes narrow, the grayish stripes wide, thus producing an indistinctly striped pattern. Middle of scutellum brown, the sides lighter. Legs grayish brown. Femora with a basal band; knees narrowly darkened with light bands above and below; hind tibiae with a wide apical band. Two small, almost spherical spermathecae present, each about 35 micra in diameter. Base of duct moderately sclerotized; a rudimentary spermatheca and a ring present. Macrotrichia present near the wing margins, especially the anterior one, and along the veins; but rare within the interior of the cells and at the base of the wing. Second radial cell included in the dark spot. Crossvein not infuscated. Light spots as follows: one on the crossvein extending slightly beyond vein M; one just beyond the second radial cell, the same shape as that of *C. stellifer* Coq. but more constricted; one more or less round, before the tip of cell R^5; one before the tip of cell M^1 and another before the tip of cell M^2; one in cell Cu^1; a small one just before the forking of vein Cu; one in tip of the anal cell; one in the base of the wing, and the base of the

[5]This species is named for Dr. Edgar Harold Hinman, Professor of Public Health at the University of Oklahoma, Norman, Oklahoma.

anal cell; one on vein M^2 interrupted by the vein, and the larger part of the spot in cell M^1; one in cell M just before the forking of vein M. Tips of veins M^1 and M^2 with light borders.

Male hypopygium (fig. 4, A and B):—Apicolateral processes well developed and divergent; both the inner and dorsal processes of the sidepiece present. Membrane in front of the aedeagus not spiculated. Inner processes of sidepiece not boat-hook shaped. Aedeagus with a high arch which does not bear posterior projections; a sclerotized membrane joining the sides of the arch near the tip; end of the terminal portion truncate. Base of the harpes not expanded, but rather shaped as a bent rod; stem swollen and suddenly tapering.

Holotype, female, Wichita Refuge (Okla.), July 3, 1947; *allotype*, male, Wichita Refuge (Okla.), June 6, 1947; deposited in the University of Oklahoma Museum.

Culicoides ousairani, new species[6]

This species is closely similar to *C. arboricola* R. and H. The study of the genitalia and the dry fly showed similarity not only to that species but also to *C. villosipennis oklahomensis* n. subsp. In general, *C. guttipennis* Coq., but not its genitalia, shows similarity.

Female:—Antennae, palpi, frons and occiput brown. The eyes are separate. Last five segments of antennal flagellum (fig. 5, C) subequal with the first eight. Third segment of palpi (fig. 5, D) somewhat longer than the second, moderately swollen with small, deep sensory pit; fourth segment considerably longer than the fifth.

Mesonotum brown, pattern basically like that of *C. arboricola* R. and H., but only the prescutellar part of it retained. Scutellum like the thorax in color; its side grayish. Metanotum like the mesonotum with a grayish pruinose spot on each side of the median line. Halters yellowish. Legs brown with dark knees, of the banded type with the hind tibia having a broad apical light band. Spherical spermathecae present, each about 40–50 micra in diameter; the base of the duct narrowly sclerotized; a rudimentary spermatheca and a narrow ring (about 5 micra) present. Wing with the macrotrichia quite dense, especially in cell R^5. Second radial cell included in a dark spot. Light spots as follows: one small oblique spot on the crossvein which does not extend beyond vein M; one just beyond the second radial cell; one in the middle of cell R^5; one on each of veins M^1 and M^2; one in the middle of cell M^1; one near the apex of cell M^2; one in cell Cu^1; one in cell M near the forking of vein Cu; two at the tip of the anal cell; one at the base of the anal cell; one at the base of the wing. Veins M^1, M^2, and Cu^1 with light borders along their tips.

Male hypopygium (fig. 5, A and B):—Apicolateral processes well developed. Aedeagus without projections; the distal tapering end of the terminal portion short, unlike that of *C. arboricola* R. and H., the proximal part long; easily differentiated from the similar species by the presence of the sclerotized membrane joining the sides of the distal part of the arch. Harpes with a foot-shaped base; they end abruptly

[6]This species is named after Dr. Sharif Ousairan, Professor of Physiology and Public Health, Teachers College, Baghdad, Iraq.

unlike those of the allied species. Inner processes of the sidepiece about as well developed as the dorsal processes.

Holotype, male, Wichita Refuge (Okla.), June 7, 1947; *allotype*, female, Wichita Refuge (Okla.), June 29, 1947; about 700 paratypes, Wichita Refuge, 1947; deposited in the University of Oklahoma Museum.

Culicoides villosipennis oklahomensis, new subspecies

With respect to size, coloration, legs, and the general wing maculation, this subspecies resemble *C. arboricola* R. and H., *C. villosipennis* R. and H., *C. ousairani* n. sp., and *C. guttipennis* Coq. The mesonotal pattern is like that of *C. arboricola* R. and H. The wings are indistinguishable from those of *C. arboricola* R. and H. and *C. guttipennis* Coq. The cross-vein light spot is large; vein Cu^2 is sometimes with, but often without light borders.

The male genitalia are distinct from that of *C. guttipennis* Coq., less so from that of *C. ousairani* n. sp. Unlike those of *C. guttipennis* Coq. they are of the usual *arboricola* genitalia size. They differ from *C. ousairani* n. sp. in the absence of sclerotized membrane near the tip of the arch of the aedeagus. They resemble, very closely, the genitalia of *C. arboricola* R. and H. except for the presence of a pair of projections on the terminal portion of the aedeagus, a characteristic in which this species resembles *C. villosipennis* R. and H.

According to the previous characteristics of the male genitalia, the cleared male of this subspecies can be well identified. The uncleared female and male can be separated from those of *C. ousairani* n. sp. by the mesonotal pattern and the large cross-vein light spot. The uncleared female can not be distinguished from those of *C. arboricola* R. and H. and *C. guttipennis* Coq. This subspecies appears to be an intermediate form between *C. villosipennis* R. and H. (the terminal portion of the aedeagus having two pairs of projections, and vein Cu^2 without light borders) and *C. arboricola* R. and H. (the terminal portion of the aedeagus without projections, and vein Cu^2 with light borders).

Holotype, male, Wichita Refuge (Okla.), June 4, 1947; 10 male paratypes, Wichita Refuge, 1947; deposited in the University of Oklahoma Museum.

ATYPICAL FORMS

Considerable variation was seen in connection with the size of each species, the coloration, the distinctness of the wing spots, the shape of the spots, and other characteristics. Some of these variations appear to be the result of poor preservation and handling.

The species found in the Wichita Refuge vary in size, from the largest species, *C. variipennis* Coq. (about 2.4 mm.) to the smallest *C. hinmani* n. sp., which is hardly 1 mm. in length. *C. guttipennis* Coq., *C. arboricola* R. and H., *C. ousairani* n. sp., *C. villosipennis oklahomensis* n. subsp., and *C. crepuscularis* Mall. rank next to *C. variipennis* Coq. in size. *C. nanus* R. and H., *C. salihi* n. sp., and *C. multipunctatus* Mall. approach *C. hinmani* n. sp. in size. The rest of the species, including *C. haematopotus* Mall., *C. stellifer* Coq., *C. hieroglyphicus* Mall., *C. simulans* R. and H., and *C. weesei* n. sp., range as intermediate-sized

species in the area. Considerable individual variations have been noticed, making size in some cases of but little taxonomic value.

In the case of *C. crepuscularis* Mall., the mesonotum has a striped pattern composed of a median brown vitta expanding near the prescutellar depression into a diamond-shaped area, and a curved brown area on either side of the mesonotum. This type of mesonotal pattern is well represented, but quite a variation occurs, in many cases at least because of the poor preservation of the material. The diamond-shaped end area of the central vitta is absent in some specimens; in others, there is not even a trace of the dark stripes. Between this latter type and the typical mesonotal pattern of the species various grades of variation occur. In some specimens the lateral dark curved stripes have lost their middle portion, becoming only two dark spots on each side.

In the same species there is quite a variation in the light spots. Two separate ones are present at the tip of the anal cell, whereas these appear usually confluent in the typical condition. Again, the relation of the light spot near the base of cell M^1 to the two spots in cell R^5 is variable; it is sometimes confluent with them, otherwise with only the first one. The size of the light spots and their distinctness is also variable, this type of variation being by no means confined to this species. Very few females possessed an extra light spot between the cross-vein light spot and that just beyond the second radial cell.

A rudimentary spermatheca is not supposed to be present in this species, but a very small rudimentary spermatheca has been seen with the associated duct in some of the females with the atypical mesonotum and light spots.

SEASONAL INCIDENCE

The end of the first week of April seems to be the beginning of the seasonal activity for the *Culicoides* in the Wichita Refuge, while the end of July appears to be the close (fig. 6). Four specimens only (of *C. haematopotus* Mall. and *C. crepuscularis* Mall.) were collected in about 45 days of August, September, and October. Variations are present among some of the species in regard to the time of emergence or disappearance in the season.

The appearance of the species in the beginning of the season is gradual and not constant. June is the most suitable month for this genus in the Wichita Refuge. The dominant species varies in different times of the season. There is a difference among some of the species in the time when they attain their peaks of abundance. In some of the species this maximum incidence continues for a few days, while in others

EXPLANATION OF FIGURE

FIG. 6. Seasonal incidence of the species of *Culicoides*, by five day periods, in light-trap, Wichita Refuge (Okla.), 1947. Incidence indicated by the percent of the total seasonal collection of the species. Number following the name of the species represents that total. A, the abundant; B, the common; C and D, the occasional species. The rare species and *C. villosipennis oklahomensis* n. subsp. are not included.

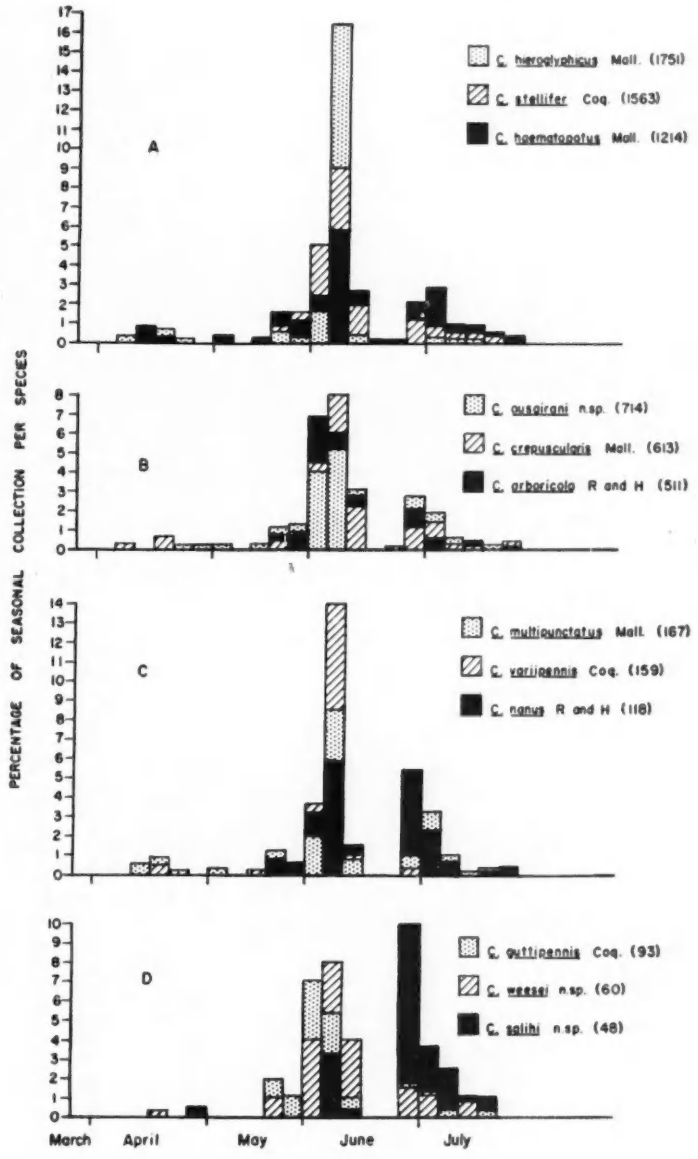
PERCENTAGE OF SEASONAL COLLECTION PER SPECIES
A
C. hieroglyphicus Moll. (1751)
C. stellifer Coq. (1563)
C. haematopotus Moll. (1214)
B
C. ousairani n.sp. (714)
C. crepuscularis Moll. (613)
C. arboricola R and H (511)
C
C. multipunctatus Moll. (167)
C. variipennis Coq. (159)
C. nanus R and H (118)
D
C. guttipennis Coq. (93)
C. wenesi n.sp. (60)
C. salihi n.sp. (48)
March
April
May
June
July

FIG. 6

it is sudden and well differentiated. There may be more than one peak for a species. There are certain days which seem to be more suitable for activity, because on such days many of the species attain their peaks. The same fact could be noticed about the time of the appearance and disappearance of the species.

Females of each species were more abundant than males. The latter sex seems to continue as late as the females in the season. There is no indication that the emergence of males precedes that of the females.

A collection was made on June 20, 1950 at a spot about 50 feet from the location of the trap in 1947 and other collections were also made a few miles away. Variations exist between the collections made for the same day in different years. The difference in the location of the trap (beside the environmental difference in the two years), although not considerable, should be taken into account especially for these insects with a limited flight range.

The time of appearance, dominance, and disappearance of the species of *Culicoides* in the Refuge differs from some other locations in the United States. This is probably the result of climatic differences, as is shown by the fact that, in the northern states, and in northern Colorado according to James (1943), most of the species attain their peaks later than July.

In spite of the lack of comprehensive work, the present situation indicates qualitative difference in the content of the *Culicoides* species in Wichita Refuge (Okla.) from those of the neighboring states. Some species are of wide geographical distribution.

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CONSOLIDATION OF THE ENTOMOLOGICAL SOCIETY OF AMERICA AND THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

In 1949, President Alvah Peterson appointed a Committee of three members of the Entomological Society of American to explore the question of the desirability and feasibility of consolidation of our two national entomological organizations. At the same time a parallel committee was appointed by President A. M. Boyce of the American Association of Economic Entomologists. Progress reports of these independent studies were made to the respective Executive Committees and the membership at the December meetings of that year (Ann. Ent. Soc. Amer., 43: 165; Jour. Econ. Ent., 43: 251). The two committees were combined and functioned as a Joint Committee in 1950, reporting to the Executive Committees at the annual meeting in December. After separate consideration the two Executive Committees approved the general plan for possible consolidation and then met jointly to consider minor changes in the proposed constitution and to agree upon a plan for submitting the question to the membership of each organization for vote (Annals, 44: 160; Journal, 44: 134). As a result the proposed constitution was read to the members at the respective business meetings and submitted to the membership of each organization for approval by mail ballot. A two-thirds majority was required in each case to effect consolidation. Consolidation was approved by the American Association of Economic Entomologists by a vote of 1224 to 217 (a majority of 84.9 per cent). However, in the Entomological Society of America consolidation lost by a vote of 416 to 226 (a majority of only 64.8 per cent) (Annals, 45: 140). This fact was reported to the Executive Committee at the annual meeting in December, 1951. After considerable discussion it was proposed by a member who had voted against consolidation that the question be submitted to a re-vote for the following reasons: (1) that the ballot had been light, (2) that it was known that some ballots had been lost in the mail (the ballots were mailed third class), (3) that there had been some confusion on the part of members belonging to both entomological societies because the ballots of the two societies were sent out within a few weeks of each other, and it was known that through misunderstanding some had not voted on the second ballot they received (the Entomological Society of America ballot), and (4) the very narrow margin deciding the vote. This motion was placed before the annual business meeting of the Society and was passed. It was also moved, seconded, and passed that the question of consolidation with the American Association of Economic Entomologists be submitted to the membership as soon as the necessary arrangements would permit, by means of a ballot, a copy of the proposed constitution and a covering letter from the Secretary stating the reasons for the second ballot, and that a deadline of May 1st or six weeks be set for the return of ballots, whichever might be the longer. In the discussion it was recommended that this material should be sent out to the membership by first class mail and this procedure was followed. The American Association of Economic Entomologists generously agreed to defer plans for re-organization and await the outcome of the re-vote. The second vote was responded to by 727 members (73 per cent of the membership) and the vote was 546 for consolidation to 181 against (a majority of 75.1 per cent).

Transition procedures are laid down in the new constitution as follows: After ratification by affirmative ballot vote of a two-thirds majority of the votes cast by the members of each of the organizations now operating under the names Entomological Society of America and the American Association of Economic Entomologists, [the new] Constitution and the appended by-laws shall become effective the following January 1 [1953]. On that date the Constitution and By-laws of the Entomological Society of America and the American Association of Economic Entomologists shall be revoked and inoperative. The members of the Executive Committees of the two above-mentioned organizations holding office on the above date shall constitute an Interim Governing Board for one year to carry the provisions of [the new] Constitution and accompanying By-laws into effect as rapidly as possible. They shall have the authority of the Governing Board, as set forth in this Constitution and accompanying By-laws, to conduct the affairs of the Society during the transition period.

From this decisive vote it is clear that consolidation has the backing of a solid majority of the members of the Entomological Society of America. Understanding the reasons which prompted members to vote against unification, it is our most sincere hope that all, regardless of their prior views, will now contribute their utmost to make the new organization a success in order that it may carry out its stated purpose "to promote the science of entomology in all its branches . . ."

E. G. LINSLEY, *President.*

THE SUCKING LICE, by G. F. FERRIS. ix+320 pages, 124 figures. Lithographed. Pacific Coast Entomological Society, Memoir I. 1951. Price, $6.00.

That a group containing such notable ectoparasites of man and domestic animals as the vector of epidemic typhus and the economically important hog louse and short nosed cattle louse should be treated comprehensively in one volume, is an event of importance in the field of systematic, medical and veterinary entomology. Dr. Ferris is the logical man to perform such a task, and he has produced a work which will undoubtedly be a standard reference in this field for many years to come. It is a thoroughly mature work, resulting from study and research spread over a period of more than thirty years.

The morphological introduction (pp. 3–49), prepared in collaboration with Chester Stojanovich, and well illustrated with remarkably clear, mostly semi-diagrammatic figures will provide a useful guide to the external and internal anatomy of the group. The chapter on growth and development is, naturally, brief, but is accompanied by almost six pages of illustrations of eggs and nymphs. Brief chapters are then devoted to an historical review and to a general discussion of classification. Most of the work (pp. 71–285) is taxonomic, with keys, characterizations of the higher group, bibliographic citations, distributional and host records, and often notes concerned chiefly with the taxonomic status of the forms discussed, but with very little descriptive material on the species level, this being rendered unnecessary because of the completeness of illustration. Each figure, though usually dealing with a single species, covers several subjects and takes a larger part of, frequently an entire, page. The illustrations are executed with the care characteristic of the author. Both a host list (pp. 286–303) and an index to most references in the text, as well as an index to the Anoplura, are given.

One valuable feature of the work is the inclusion of discussions concerning certain moot questions in the taxonomy of the group, such as the nomenclatorial and zoological tangles involved in the identity of the hog louse and the problems of human *Pediculus*. Dr. Ferris does not simply state his conclusions; rather he presents the arguments in brief, with reasons for his conclusions.

We feel that the Pacific Coast Entomological Society has made a very fine start in its *Memoirs* series. It will be a high standard to maintain.—M. T. J.

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Members failing to receive their numbers should present the complaint to the Managing Editor within four months from the date of the mailing of the issue. After that time the numbers will be furnished only at the regular published rate. Requests for membership should be sent to the Secretary, Dr. A. C. Hodson, University of Minnesota, St. Paul 1, Minnesota, and annual dues of members to Dr. S. W. Frost, Pennsylvania State College, State College, Pennsylvania.

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